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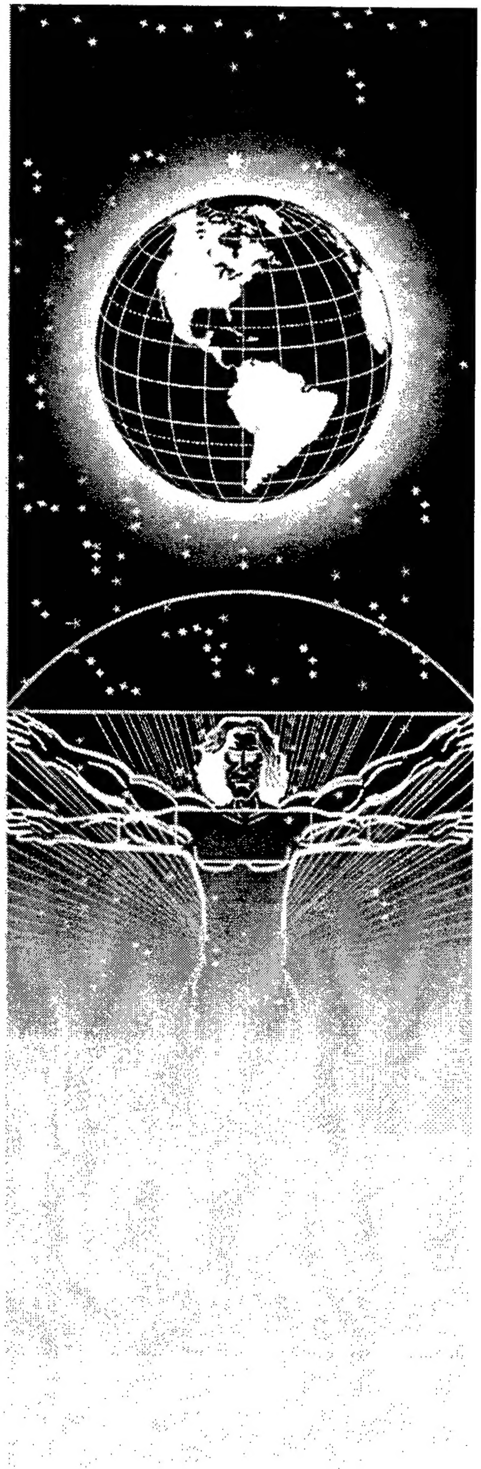

UNITED STATES AIR FORCE RESEARCH LABORATORY

AN EVALUATION OF REQUIRED TOOLS FOR THE IMAGERY ANALYST

The Technical Staff

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OCTOBER 1997

INTERIM REPORT FOR THE PERIOD OCTOBER 1995 TO SEPTEMBER 1997

Human Effectiveness Directorate
Crew System Interface Division
Wright-Patterson AFB OH 45433-7022

NOTICES

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This report has been reviewed by the Office of Public Affairs (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

FOR THE COMMANDER

Hendrick W Ruck

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The drawdown in the military forces of the United States is leading to a reduction in both the numbers and experience level of trained imagery analysts. At the same time, emerging reconnaissance and surveillance system capabilities show great promise of increasing the coverage rates and sensed phenomenologies which may be obtained over the future battlefield. Automation may alleviate this "data overload" problem but only if it is applied with significant forethought. In order to prepare for technology insertion, the system designer must have a thorough appreciation of the tasks and preferred tools of the imagery analyst.

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PREFACE

This survey of imagery analyst tasks and exploitation tools was conducted by the Technical Staff of Adroit Systems Incorporated, Fairborn, Ohio, under subcontract to Logicon Technical Services Inc., Dayton, Ohio. The prime contract, F41624-94-D-6000, was monitored by Mr. Donald Monk (AL/CFHD). The effort was performed in support of the Collaborative Systems Technology Branch, Human Engineering Division, Crew Systems Effectiveness Directorate, Armstrong Laboratory, Wright-Patterson Air Force Base, Ohio. It was conducted under United States Air Force Work Unit 71841044, "Crew-Centered Aiding for Advanced Reconnaissance, Surveillance and Target Acquisition." Mr. Gilbert G. Kuperman (AL/CFHI) was the Work Unit Manager.

This effort was partially supported by funding received from the Reconnaissance Systems Program Office and also by the Theater Missile Defense Attack Operations Project Office of the Aeronautical Systems Center (ASC/RA/FBXT), Wright-Patterson Air Force Base, Ohio. Special thanks are also due to Dr. Robert Hummel of the Information Systems Office, Defense Advanced Research Projects Agency (DARPA/ISO), program manager for the Interactive Imagery Exploitation (InImEx) Program, for his commitment to giving imagery analysts control over automated target cueing and recognition aids.

The authors wish to thank the dedicated men and women of the United States Department of Defense who provided the subject matter expertise reported herein. Their professionalism and enthusiasm contribute markedly to maintaining a strong national defense.

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SECTION I

BACKGROUND

Imagery interpretation is a combination of mathematics, science and art. The first reported use of aerial imagery interpretation was during the Civil War. Photographers were placed in tethered hot air balloons and were sent aloft to photograph the battlefield. The photographs were in turn handed to the battle field commander to examine the position of troops preparing for battle. Imagery interpretation has greatly advanced since its humble beginnings. The intelligence field has migrated from silver plates to soft-copy computer readable imagery provided in near-real time.

Imagery is collected by a host of programs and platforms including; satellites, manned platforms including the SR-71, P-3, and U-2, and most recently Unmanned Aerial Vehicles (UAV's). With the advent of long endurance UAV's with multi/hyper-spectral and, soon to be, ultra-high-resolution Synthetic Aperture Radar (SAR) sensor capabilities, the average volume of imagery products will increase rapidly. In Desert Storm, one agency reported producing an average of 142,000 images daily. That same agency is now striving to produce 16,500 images per hour - triple the rate. Periods of national crisis or conflict cause these requirements to escalate to an estimated 10 fold.

Approximately 1800 of military imagery interpreters or analysts (IAs), are required to analyze and evaluate these products today. Nearly 800 of these are Air Force personnel.[1] The need to handle this expected growth is apparent. Effective exploitation methods with efficient and automated tools are being sought, but the human decision-maker will still be required as the critical link in the intelligence exploitation process.

[1] According to a 1996 Scientific Applications International Corporation (SAIC) study on imagery analysts

SECTION II

PURPOSE

The human is the most important factor in the exploitation process; second are the tools of the trade. For an effective operation there must be a marriage of functionality and "usability." This marriage is captured within the Human-System Interface (HSI) technologies. In order to better understand the users' needs, a survey was conducted of IAs operating in a field deployed status (this was a consideration to minimize any impact on operational real world requirements). This survey is part of a larger effort being conducted between the Air Forces Armstrong Laboratory (AL) and the Aeronautical Systems Center (ASC) to design a better Human Machine Interface (HMI) for sensor imagery exploitation. The purpose of the overall effort is to define, develop, refine, evaluate, and demonstrate HSI technologies applicable to the integration of imagery exploitation functions and to use this knowledge to enhance workstation capabilities, thus increasing throughput while minimizing analyst workload.

This report outlines the results of the survey given to IAs. It reflects their concerns and views of the use of typical operational exploitation workstations. The survey intent is to explore current IA functions performed on Advanced Synthetic Aperture Radar System (ASARS), Electro-Optical (EO) systems, Moving Target Indicator (MTI) systems and/or to identify the combinations of tools required to fully exploit imagery from these systems.

SECTION III

METHOD

Location

The surveys were administered in exercise deployed locations including; Gold Pan 95-1 (Spring 1995), Gold Pan 95-2 (Fall 95), Roving Sands 97 (Spring 97), and in Mainz Finthen, Germany (Summer 1995). The original intent of this study was to provide insight in the entire IA exploitation spectrum including all types of sensors and products. However, the scope, experience levels and limited responses of the survey the primary focus will be restricted to ASARS exploitation.

Subjects

A total of twenty-four IA subject matter experts (SMEs) participated in this survey. (This number reflects approximately 1% of the actual number of active duty analysts). The analysts represented both the Air Force and Army. The imagery interpreters are known by many pseudonyms including IA, imagery interpreter (II), and photo interpreter (PI). For the remainder of this study they will be referred to as either analysts or IAs.

Procedure

The survey was initially conducted with two groups. Both took the form of tape recorded interviews with the participants. Four analysts were interviewed at Gold Pan, and six at Mainz Finthen. (No individual statistics were gathered during this portion of the activity.)[2] The Gold Pan 95-1 subjects were interviewed in the MIES (Modernized Imagery Exploitation System) trailer. Background information was recorded from the IAs who participated in this portion of the survey. The interviewer then orally administered the survey to the group, tape recording the discussion. A similar procedure was followed at the Mainz Finthen session except the interviewer recorded the group response on a blank survey form (due to recording equipment failure). The remaining 14 SMEs responded via a formal, pre-printed questionnaire. The questionnaire was administered on non-fly mission days during the various exercises. The IAs were afforded as much time as they needed to complete the survey. An on site review of each questionnaire was conducted by the survey administrator to clarify responses, and to provide additional insight not provided by the initial survey responses.

Disclaimer- Due to the limited survey sample size (1 percent) and the composite make-up of analyst groups (i.e., no senior Air Force technical staff inputs, no Navy or Marine analysts, no government agency IAs , nor other civilian representatives), this survey will not completely represent an accurate information capture of the entire IA field.

[2] However all their comments regarding the issues were transcribed and incorporated into this report

SECTION IV

RESULTS

Experience

Military Experience

The number of years of military experience varied within the sample group. Many unclassified reports, including Joint Vision 2010, have indicated that a severe decline in the experience level of IAs has occurred. The results of this survey may be an artifact of this recent trend. All of the Air Force representatives held the rank, see Table 1, of E-3 or below, whereas one Army analyst was an E-3, three were E-4s, one E-5, and one Warrant Officer WO-1. This distribution of ranks is somewhat higher than might have been expected.

Several meaningful conclusions could have been drawn from rank or experience levels if a larger sample size could have been obtained. Such conclusions might have included: that the Army's promotion or retention programs are better; that the Army provides only senior non-commissioned officers for exercise support; that the Army core group of IAs are more experienced than their Air Force counterparts. Given the actual sample size, these observations must be considered to be conjectural.

E-2	E-3	E-4	E-5	WO-1	Total
1 1 (AF)	8 7 (AF), 1 (AR)	3 3 (AR)	1 1 (AR)	1 1 (AR)	14

Table 1 Military Rank of SMEs

Training

All of the respondents were qualified and trained (in military service schools) as IAns, see Table 2. Eight of the analysts were from the Air Force while six were from the Army. All of the respondents had received basic training at Goodfellow AFB, Lackland AFB, or Fort Huachuca training facilities. Only four of the analysts had any advanced imagery training. Three of them had received additional formal training at Goodfellow AFB and one at the Defense Sensor and Intelligence Application Program Training (DSIAPT) Center. All 14 IAs had received extra "on-the-job" training.

Schools	Goodfellow AFB	Lackland AFB	Ft. Huachuca	Other
Basic service School	5 (AF)	3 (AF)	6 (AR)	
DSIAPT				1 (AR)
Advanced Service School	3 (AF)			1 (AR)
OJT				8 (AF), 6 (AR)

Table 2 SME Training

Skill Types

Test and Evaluation

All 14 subjects were, or had been, actively involved in some aspect of design, development, or testing of new imagery exploitation systems. Thus, they could be presumed to be open-minded regarding new or enhanced exploitation capabilities.

Phases of Exploitation

There are three general phases of exploitation, see Table 3. Phase 1 is the initial readout to determine significant changes in order-of-battle, facilities, or bomb damage assessment since the last imagery report or since a search of new activity was conducted. Phase 2 is a more detailed examination of the imagery. This would include such items as a facility change, the identification of new construction, or the modification to known equipment. Phase 3 is the most time intensive exploitation; it requires a full detailed analysis of the imagery, facility, or equipment. It includes a review of the historical imagery that normally results in precise targeting products or in-depth analysis. The entire group of analysts had 1st phase readout experience, and nine of the 14 subjects were involved with the 2nd and 3rd phase exploitation work.

Types of Exploitation	Phase I	Phase 2 & 3
Number of Ias	AF–8 AR–6	AF–6 AR–3
Total	14	9

Table 3 Phase Readout Experience

Experience with Various Sensors

IAs are often tasked to exploit more than one type of imagery product, see Table 4. This can include EO, ASARS, video, tactical reconnaissance wet film imagery, positive transparency or print photographs, MTI and Multi-Spectral Imagery (MSI). The primary imagery products investigated in this study were ASARS, EO, MTI, and MSI. All subjects had a minimum of ASARS and EO imagery experience, with an average level of

experience of one year with both exploitation systems. Only three analysts had more than four years experience using both systems.

No. Years Sensors	3 Yr. + AF+AR	2 Yr. + AF+AR	1 Yr. + AF+AR	< 1 Yr. AF +AR	Mean Yr. AF+AR	Median AF+AR	Mode AF+AR	Total IAs AF+AR
ASARS	1	2	7	3	1.2	1	1	13
EO	2	1	8	3	1.3	1	1	14
MTI	0	0	0	2	0.25	0	< 1	2
MSI	2	0	1	0	2.3	0.5	3	3
Comb. Total	5	3	16	8	- -	- -	- -	-

Table 4 Years of Sensor Experience per Analyst

The authors found that the small number of analysts with other than ASARS or EO experience to be alarming. Only three analysts reported any MSI experience, and only two had MTI experience. The two with MTI experience had only 3 months each, while two of the three with MSI experience had three years each. Basic knowledge of all operational and future systems is critical for supporting crisis situations. Often it is the case that IAs are assigned to support operational missions in a temporary assigned duty (TAD) status. If the IAs are not familiar with, or have not had formal training in a sensor system, precious time is lost in training and bringing them up to speed. Additionally, lack of training may lead to inaccurate or erroneous reporting. Having inexperienced operators is nearly as bad as not having any sensors. The lack of MSI and MTI experience was to be expected due to the limited current operational employment of MSI and MTI sensors.

Years	3 Yr.		2 Yr.		1 Yr.		¾ - ¼ Yr.		Mean Yr.		Median		Mode		Total IAs	
Sensors	AF	AR	AF	AR	AF	AR	AF	AR	AF	AR	AF	AR	AF	AR	AF	AR
ASARS	0	1	1	1	5	0	1	2	1.1	1.3	1.0	1.5	1	1	7	4
EO	0	2	1	0	4	2	1	2	1.4	1.5	1.0	2.0	1	2	6	6
MTI	0	0	0	0	0	0	0	2	0	0.6	0	0.3	0	0	0	2
MSI	0	2	0	0	1	0	0	0	1.0	0	0	0	0	0	1	2
Comb. Total	0	5	2	1	10	2	2	6	-	-	-	-	-	-	14	14

Table 5 Sensor Experience by Service

Sensor Operations

For situation awareness purposes and to comprehend system capabilities, it is important that the analyst understand the various sensors and how they operate. The analyst relies on the understanding of operational modes, slant ranges, shadows, and look angles to derive additional information from the source imagery. Fifty percent of the respondents claimed they were fairly certain they knew how sensors operate. Serving as a collection

manager, analysts gain an appreciation of sensor operations and tasking. Only four of the IAs had collection management experience.

	Agree (1)	(2)	(3)	Neither Agree nor Disagree (4)	(5)	(6)	Strongly Disagree (7)	Mean Agree-ment	Median Agree-ment
Air Force	1	0	3	1	0	0	0	3.3	3
Army	5	1	0	2	0	0	0	2.1	1.5
Totals	6	1	3	3	0	0	0	2.0	3

Table 6 Knowledge of Sensor

Image Quality Rating Abilities

IAs use a standardized, subjective method of determining image quality. This method is known as the National Imagery Interpretation Rating Scale (NIIRS). NIIRS is applicable to all forms of imagery and radar. The scale runs from 0-9 (non-exploitable to excellent). This is typically reported in intelligence reports to provide the recipient an indication of the quality of the imagery and an indication of the confidence to be ascribed to the analysis. Only six (55%) of the IAs felt qualified in the National Imagery Interpretation Rating Scale (NIIRS) and its application and only 10 of the SMEs had received training in the use of the NIIRS. These 10 IAs were split: five Air Force and five Army.

	Yes	No
Feel Qualified in NIIRS Interpretation	6	5
Feel Qualified in Radar NIIRS Interpertation	5	5

Table 7 NIIRS Experience

Experience	Yes	No	% w/ training
Air Force	5	3	62.5 %
Army	5	1	83 %
Totals	10	4	71 %

Table 8 NIIRS Training

Operational/Exercise Deployments

None of the interviewees (with exception of those deployed to Mainz Finthen) had been operationally deployed to locations like Joint Task Force Southwest Asia, Bosnia, or Korea. Forward deployments, see Table 9, though not essential to intelligence operations, provide operational experience and insight into the actual worth of intelligence support missions.

Location	Air Force	Army	Duration
Edwards AFB		6	2-4 months
Ft Campbell		1	2 weeks
Seymore Johnson AFB		1	2 weeks
Roving Sands	4	6	2 weeks-4 mo.

Table 9 Deployment Experience

Exploitation and Intelligence Support Tools

The analysts employ a host of tools to enable them to interpret and analyze imagery products. These range from various types of intelligence databases, to unique variants of exploitation software, and, perhaps even unique types of support vans. Experience with these systems is critical to support various joint operations. In today's military environment analysts are required to forward deploy to numerous locations and operate unfamiliar equipment. Operations and tools at the Combined Air Operations Center (CAOC) in Vincenza, Italy, are different than those employed at Joint Task Force Southwest Asia, Korea Combined Operations Intelligence Center (KCOIC), or even in Washington DC at national level exploitation centers. The more well rounded intelligence analysts have become due to increased exposure to modern equipment and software, the more quickly they will assimilate yet newer environments. Thirteen of the 14 IAs had some experience operating with the traditional light table. The Army participants, as expected, had more experience with the Army's Enhanced Tactical Radar Correlator (ETRAC) and MIES exploitation vans. Two of the Air Force IAs were also familiar with ETRAC operations. Three of the Air Force IAs were experienced with the Contingency Airborne Reconnaissance System (CARS), while the Army was represented by one CARS-experienced IA. Two Air Force respondents were familiar with CARS II, and four had Joint Services Image Processing System (JSIPS) experience. The Army SMEs had no experience with either of these latter two systems.

Total experience with exploitation and dissemination is reflected in Table 10. The majority of the analysts had experience with Demand Driven Direct Digital Dissemination (5D) or Joint Deployable Intelligence Support System (JDISS). [3]

[3] This survey was administered prior to wide distribution of the Intelligence Product Archive dissemination system.

ACTIVITY	NUMBER IAs		AVERAGE Experience	
	Air Force	Army	Air Force	Army
Light Table	7	6	7 mo.	30 mo.
5D/JDISS	8	3	9 mo.	24 mo.
ELT	0	1	0 mo.	4 mo.
CARS	3	1	9 mo.	6 mo.
CARS II	2	0	13 mo.	0 mo.
ETRAC	2	6	1 mo.	16 mo.
MIES	0	6	0 mo.	20 mo.
FIST	0	3	0 mo.	36 mo.
JSIPS	4	0	10 mo.	0 mo.
IDEX	2	2	1 mo.	39 mo.
DIEPS	2	2	1 mo.	11 mo.
MATRIX	0	6	0 mo.	21 mo.
NDS[4]	0	0	0 mo.	0 mo.
IESS	1	0	24 mo.	0 mo.

Table 10 Exploitation Tool Experience

Pre-Mission Preparation

Mission Tasking

The respondents received their mission and exploitation tasking from either the collection manager or directly from the J-2. For both ETRAC and CARS systems, the mission supervisor directs mission or exploitation tasking.

Databases

Intelligence support databases vary widely. They support historical imagery coverage, tasking and exploitation requirements, and target information derived from previous coverage. The analysts draw on data bases in their normal routine to evaluate targets. The databases found to be most widely operated or maintained were: AIRES, CATIS, IESS, Message Traffic, Target Folders, and Reference Imagery. The most widely used tools were: reference imagery and target folders. Ten of the 14 subjects claimed they spent one hour setting up, researching the databases, and acquiring the materials prior to

[4] NDS is the NIMA Data System and supports analysts operating at national level exploitation centers.

mission work. The types of databases are depicted in Table 11, while Table 12 highlights the primary source preference.

Databases	Air Force	Army	Total	Mean
Target folders	6	5	11	5.5
Reference Imagery	6	4	10	5.0
MSG Traffic	3	5	8	4.0
AIRES	3	4	7	3.5
CATIS	3	1	4	2.0
Others (list) - IESS	4	0	4	2.0
SIDS	2	1	3	1.5
SAFE	1	1	2	1.0
MIDS/IDB	0	2	2	1.0
Local	1	1	2	1.0
Combat CATIS	0	0	0	0
Constant Source	0	0	0	0
NIPS	0	0	0	0

Table 11 Database Usage

Mapping, Charting and Geodesy Products

Maps and charts enable the analyst to obtain geographic references against which to correlate the imagery. Maps provide the basis for targeting and situational awareness. They are used to orient the imagery, to determine location, and to provide geolocational fixes for the targets and the offset aim points.

The Army analysts usually had both computerized and hard copy maps while the Air Force analysts had only the hard copy maps. Most analysts preferred the computerized maps and quite strongly agreed they had adequate area coverage with which to work. The Army personnel preferred maps of 1:250K (JOG) and 1:50K scale, while the Air Force respondents preferred 1:250K (JOG) and 1:500K (TPC) scale maps, see Table 12. The four Air Force respondents spent less than five minutes (four said "none") arranging and configuring their maps prior to mission analysis. The Army analysts reported 30 minutes were spent doing their set-up (it was not clear if these 30 minutes are included in the hour claimed for pre-mission database and material set up). The most frequent utilization of map products were for orientation and mission coverage plots. All of the analysts surveyed would like to have previously identified targets labeled in their reference window.

Map Size	1st Preference		2nd Preference		3rd Preference		4th Preference or <	
	AF	AR	AF	AR	AF	AR	AF	AR
GNC	0	0	1	0	0	0	4	3
JNC	2	0	0	0	3	0	1	2
ONC	0	0	0	0	3	1	4	1
TPC	0	0	4	0	0	0	0	3
JOG	5	4	0	2	1	0	0	0
1:50000	0	4	0	1	2	2	3	0
1:10000	0	0	0	0	0	0	1	2

Table 12 Map Scale Preferences

Mission Exploitation

Mission exploitation is considered the normal result of the IA processes while performing their primary function as analysts. Even though the IAs perform similar or related tasks, there was no single task or mission in common to all, see Table 13. Greater than 10 out of the 14 subjects worked on: training, report writing, Phase I exploitation, and order-of-battle exploitation. No estimate of time spent on these areas were given and there was no general consensus as to whether more time was spent on national, theater, or tactical imagery.

Situational Awareness

A significant portion of mission exploitation requires situational awareness; this includes understanding of the sensor capabilities, route, and location. Eight of the 10 analysts stated they knew the location of the sensor platform and felt that this was very important. The IAs were asked questions on pre-mission electronic maps with overlay information pre-noted on them. Generally, the responses were fairly evenly split as to their usefulness. The IAs were exactly split as to whether they felt an electronic map overlay would be beneficial: five said "No," four reported "Somewhat," and five answered "Yes." Asked whether a pre-mission trace on their map would be useful, again they responded with a fairly even split: four responded "No," six answered "Yes," and three did not know (and did not reply to this question). The group was also split on the usefulness of an electronic map overlay verses a hard copy: four said "No," five said "Neither agree nor disagree, and four reported "Yes."

Mission Performed	Air Force	Army	Total
Training	6	6	12
Report Writing	7	5	12
First Phase Exploitation	6	6	12
Order of Battle	6	4	10
Search	3	6	9
Mission Planning	0	6	6
Special Ops. Support	0	6	6
Bomb Damage Assessment	0	5	5
Targeting	0	5	5
Quality Control	3	2	5
Second Phase Exploit	3	2	5
Collection Management	0	4	4
I & W	3	1	4
Treaty Verification	2	0	2
S & T	0	1	1
Third Phase Exploit	0	1	1
All Source	0	0	0

Table 13 Types of Exploitation Missions

Production

On the average, most interviewees exploit between 40 and 60 images per day, while they produce an average 10-20 secondary image dissemination products (SIDS) from those images. They also review between 20 and 40 additional previously exploited products. The Army analysts indicated that, on average, they exploit more imagery than their Air Force counter-parts, see tables 14-16.

	10-20	20-40	40-60	60-100	100<	Mean	Median	Mode
Air Force	2	2	2	0	0	32	20-40	N/A
Army	1	0	2	2	2	68	40-60	N/A
Total	3	2	4	2	2	51	40-60	40-60

Table 14 Images Reviewed Per Day

	10-20	20-40	40-60	Mean	Median	Mode
Air Force	0	3	0	20-40	20-40	20-40
Army	4	1	1	20-40	10-20	10-20
Total	4	4	1	20-40	20-40	N/A

Table 15 SIDS Products Reviewed

	10-20	20-40	40-60	60-100	100<	Mean	Median	Mode
Air Force	2	5	2	0	0	31	20-40	20-40
Army	5	1	3	2	2	40	40-60	10-20
Total	7	4	5	2	2	45	40-60	40-60

Table 16 Total Images Reviewed Daily

Daily Shift Routines

The average daily shift at the 13th I.S. is 4-8 hours, while at the 30th I.S. is 8-12 hours. All strongly agreed their 4-8 hour shift was sufficient in length (not too long) and they could take breaks as needed.

Shift Length (hrs.)	Air Force	Army	Total
1-4	0	0	0
4-8	3	0	3
8-10	3	5	8
10-12	1	1	2
>12	0	0	0

Table 17 Average Shift Length

Effects of Imagery Exploitation Shift Work

The majority of analysts reported no adverse health effects resulting from their exploitation duties. However, four IAs reported suffering from either fatigue, headaches, or eyestrain. Additionally, one felt that long periods of exploitation work affected their overall performance.

	Not Affected (1)	(2)	(3)	Somewhat Affected (4)	(5)	(6)	Significantly Affected (7)	Mean	Median	Mode
Air Force	3	1	0	1	0	0	0	(2)	(1)	(1)
Army	2	3	0	0	0	0	0	(2)	(2)	(2)
Totals	5	4	0	1	0	0	0	(2)	(2)	(1)

Table 18 Affect of Fatigue during a Mission

Information Flow

Information flow is the speed of the information, which the analyst must exploit. One primary concern is that analysts maybe "overtasked" (i. e., having more tasks to perform than time available for their performance) by current systems or sensors. As shown in Table 19, the tasks are generally distributed appropriately.

	Under-Tasked (1)	(2)	(3)	Appropriate Tasking (4)	(5)	(6)	Over-Tasked (7)	Mean	Median	Mode
Air Force	0	0	0	7	1	0	0	(4)	(7)	(4)
Army	0	0	3	1	1	0	0	(4)	(3)	(3)
Totals	0	0	3	8	2	0	0	(4)	(4)	(4)

Table 19 Flow of Information during a Mission

Search Imagery Processing

Intelligence collection platforms provide search imagery for the analyst. This search imagery typically covers a large or broad area of the Earth's surface. For example, the SR-71 can cover 834 sq. nm. in a single frame of imagery. This type of imagery is excellent for locating new targets, mapping large areas, and identification of troop movements, etc. Normally, this imagery is not of the same quality (i. e., resolution) as spot mode or point target coverage (other, higher resolution, imaging modes). Exploiting search imagery is similar to a treasure hunt. An analyst may search 100s of square miles of imagery coverage just to locate one new item of interest. Once new activity has been identified, the analyst can request additional coverage of the target area. On average, most analysts will devote more time per image when performing first phase exploitation of search mode imagery than to exploiting point target mode sensor material.

All analysts do real-time target searches. Six of the 14 analysts (43%) responded they do search 25-50% of the time, and seven out of 12 respondents claimed they had sufficient time to complete their target search before new information arrived. But, two thirds agreed they could use another 10-30 seconds per image. Using ASARS, one third of the IAs responded that it takes 30-60 seconds to receive a search image, and 12 of the 14 responded they felt the time allotted to maintain one's perspective, and to remember the subject, was just about correct. All responded that maintaining situational awareness is very important. Fifty percent (seven of the 14) responded they never measure targets

from the search mode, while five of the 14 responded they measure less then 25% of them.

Point Target or Spot Mode Imagery Exploitation

In contrast to search imagery, point target or spot imagery is typically comprised of higher quality images which cover a considerably smaller geographical area. Point target mode of operation is used to identify activity within a specified area. It provides more detailed information (depending on imagery quality) on specifics such as: composition, size, and quantities. Analysts can identify most types of objects (i. e. specific type tanks or aircraft), and accurately measure the dimensions of these objects. Depending on the mission and type imagery taken, the IAs can identify and assimilate changes to targets. Therefore, for familiar targeted areas, the analyst can quickly assess the situation and move on. New targets and unfamiliar targets present more of a challenge, thus the analyst tends to spend more time on them.

In spot mode, five of the 14 IAs responded they measure objects between 50-75% of the time, and seven of the 14 said they measure objects 75-100% of the time. All 14 use, and prefer, coarse spot imagery (to search mode imagery) for these exploitation tasks due to the enhanced detail. Coarse spot was also preferred over fine spot (a still higher resolution mode) because it provides better overall coverage of target areas then fine spot.

Exploitation Tasking

Exploitation requirements are normally decided at the time of collection request submittal. Each organization regulates and assigns tasking differently. Within CARS and ETRAC, the Mission Supervisor derives how each mission is to be exploited. These assignments can be tasked based on skill level, experience, target specific expertise, or general target type.

One third (five) of the respondents said one or two image analysts were used for general search, one third (four) of the group said three or four IAs were used, and one third (five) said five or six analysts were assigned to conduct this type of exploitation. All agreed that, in their experience, no one specified which IAs were to do the search imagery exploitation when it arrived. Eight of the 14 IAs (the majority) responded that three of four analysts participated in the spot mode analysis and that this type of work was metered out as it arrived in a dynamic team assignment approach.

Communications

In the intelligence community, communications are extremely vital to successful operations. Communications are not restricted to external organizations, but also include intraorganizational communications.

Eight of the IAs indicated that verbal communication problems exist between the IAs (six of the respondents disagreed), see Table 20. Seven respondents strongly agree that there exists an electronic communications problem between the IAs, while five responded there was little to no intra-team communication problem as they could talk directly with each other, see Table 21. Six of the 14 reported that communication problems with other agencies stem from lack of coordination, and five of the 14 said it was from a lack of

personnel contact (reflected in Table 22). There was no correlation between the Army and the Air Force on these questions.

	Strongly Disagree (1)	(2)	(3)	Neither Agree nor Disagree (4)	(5)	(6)	Strongly Agree (7)	Mean	Median	Mode
Air Force	2	2	1	0	0	1	2	(3.5)	(2.5)	N/A
Army	1	0	0	0	0	0	5	(6)	(7)	(7)
Totals	3	2	1	0	0	1	7	(4.6)	(6.5)	(7)

Table 20 Verbal Communication Problems

	Strongly Disagree (1)	(2)	(3)	Neither Agree nor Disagree (4)	(5)	(6)	Strongly Agree (7)	Mean	Median	Mode
Air Force	0	1	0	3	0	0	2	(4.7)	(4)	(4)
Army	0	1	0	0	0	0	5	(6.2)	(7)	(7)
Totals	0	2	0	3	0	0	7	(5.4)	(7)	(7)

Table 21 Electronic Communication Problems

Problems	Air Force	Army	Total
Lack of coordination	0	6	6
Lack of contact personnel	3	2	5
None	3	0	3
Lack of clear circuits	0	2	2
Lack of time	0	0	0
No viable comm. system	0	0	0
Lack of comm. tools	0	0	0

Table 22 Typical Communication Problems

Data Correlation

Data correlation is the act of compiling and interpreting various forms of information and then developing a concise detailed analysis of the situation. A prime example of this would be the report of a certain type of radar activity on a certain day when imagery revealed that a new unknown object was located in close proximity to the location of a suspected radar signal. The analyst could deduce that the object on the imagery might be the suspected radar. Henceforth, the analyst has fused information for his report.

Two thirds (4 out of 6) of the Army respondents strongly disagreed they manually fuse their data with that from other systems while half of the Air Force respondents (four of the eight) neither agreed nor disagreed with this assertion, see Table 23.

	Strongly Disagree (1)	(2)	(3)	Neither Agree nor Disagree (4)	(5)	(6)	Strongly Agree (7)	Mean	Median	Mode
Air Force	0	2	0	4	0	0	1	(4)	(4)	(4)
Army	0	0	0	1	0	0	4	(6.4)	(7)	(7)
Totals	0	2	0	5	0	0	5	(5)	(4)	(N/A)

Table 23 Manually Fuse Data from Other Sources

Operator Aids

Mission Retention

All the IAs claimed they used prior mission source data for training aids and as preparation tools for upcoming exercises. Ten of the 14 IAs felt that these "playback missions" were very effective for mission rehearsal versus real tasking and two of the IAs felt they were only "somewhat effective."

Automatic Target Cueing

Employment of a variety of new sensor suites including UAV's and will mean the IA will be provided 10 times as much imagery than they currently receive. Data "over-sourcing" is expected to become one of the critical problems facing future intelligence operations. To solve this problem, the IA must be relieved of some of the labor intensive searches, mundane, or repetitive operational tasks and functions. Methodologies for addressing this problem include the possible application of smart algorithms including data fusion, area-delimitation, automatic target recognizers (ATRs) and automatic target cuers (ATCs). ATCs are advanced algorithms designed to help analyst detect highly probable target areas.

The Semi-Automated Imagery Process (SAIP) program (being carried out by the Information Systems Office of the Defense Advanced Research Projects Agency) is incorporating many of these developing, image processing capabilities. SAIP is not intended to become a new independent ground station, but will be a suite of tools to aid the exploitation process. If proven successful, SAIP will greatly aid the C^4I process by providing the identification, recognition, classification, and location of targets. SAIP technologies are emerging in areas of data registration and geolocation, feature extraction, exploitation, and HCI.

Seven of the 10 IAs that answered questions on ATC did not use them, but had used them in the past. Four of them reported ATC as "useful," five of them as "somewhat useful," and one didn't respond to the question. All IAs wanted the capability to toggle ATCs On or Off, and 10 of the 14 IAs wanted the capability to adjust the ATC bias (i. e., the operating point which determines the tradeoffs between correct target detections, missed detections, false alarms, and correct non-target rejections). Nine of the 14 (two-thirds)

thought a target-bounding polygon-box to be the best icon shape for depicting a possible ATC target location, see Table 24.

	Not Useful (1)	(2)	(3)	Somewhat Useful (4)	(5)	(6)	Very Useful (7)	Mean	Median	Mode
Air Force	0	0	0	1	0	2	1	(5.8)	(6)	(6)
Army	0	0	1	1	2	1	0	(4.8)	(5)	(5)
Totals	0	0	1	2	2	3	1	(5.1)	(5)	(6)

Table 24 Usefulness of ATC in Helping to Focus on Target Areas

Automatic Target Recognition

ATRs are designed to recognize particular target shapes and provide an indication on the IA's workstation imagery display. They can also provide a self-generated "confidence" index associated with each target declaration.

As a group, the SMEs were not sure about their confidence in the utility of ATRs in supporting exploitation tasks; five were "neither confident nor non-confident," three were "a little non-confident," and six were "a little confident" in ATRs. No one was definitely confident or non-confident in them.

Seven IAs said they could neither relax nor trust ATRs, while one said they could not trust them, and one reported they could trust them.

	Strongly Disagree (1)	(2)	(3)	Neither Agree nor Disagree (4)	(5)	(6)	Strongly Agree (7)	Mean	Median	Mode
Air Force	0	2	2	3	1	0	0	(3.5)	(3.5)	(4)
Army	0	1	1	2	1	1	0	(4)	(4)	(4)
Totals	0	3	3	5	2	1	0	(3.6)	(4)	(4)

Table 25 Confidence Using an ATR

Eight of the 14 IAs didn't know if they wanted to have an ATR overlay to help them search for targets; three said "Yes," and one said "No." Nine IAs felt they would be "somewhat useful" in the exploitation of high-resolution imagery. If ATRs were available, they all wanted to be able to turn on and off the system and 12 of the 14 wanted to control the sensitivity of the bias. Nine felt an icon symbol identifying a potential target might slightly influence their decision process. Twelve IAs indicated that using the an icon to highlight the suspected target was acceptable (as opposed to an alphanumeric message). If confidence levels were provided with ATRs, 12 wanted the index placed beside the target icon and all wanted to have the capability to toggle it on or off. With the confidence level displayed, seven IAs felt their decision making process would be somewhat affected, while five neither agreed nor disagreed.

User Aids

User aides are functions that enable the IAs to better perform their assigned tasks. Their capabilities may vary markedly between different exploitation systems. Common user aides include brightness and contrast controls, measuring devices or mensuration tools and annotation support tools. Less common tools include advanced enhancements such as recognition aides or (softcopy) interpretation keys. Newer advanced enhancement aides include lines of communication, area delimitation, and mapping tools.

Dynamic tasking is the ability to retask the collection sensor in a near real-time environment. IAs have little control over retasking or target designation. However, three of the analysts "strongly agreed" they wanted better control from their terminal for the dynamic tasking of the collection assets, while seven IAs did not answer the question, and three had no preference. Three IAs wanted to be able to select their own areas of interest and targets, six did not answer the question, and three didn't care. Four of them did not care if they had more target/object recognition keys; four didn't answer the question, and the remaining six were scattered: three partially for and three partially against having such on-line references. Four of the 14 IAs claimed their recognition keys were not automated, four never answered, and three "neither agreed nor disagreed." Fifty percent (seven) of the IAs would like the recognition keys to be automated, four never answered, and the rest of the answers were scattered.

Lines of Communication

Lines of Communication (LOCs) are key features including railroad tracks, roads, and rivers. LOCs can be either sources of targets (i.e., convoys, ships, trains) or identification features for orientation. The majority of LOCs are identified on maps or charts.

In general, 10 analysts felt that a LOC overlay might be "somewhat useful" and nine felt it would be "somewhat more useful" in search than spot or point mode, see Table 26. Ten of the 14 analysts agreed they would use a LOC overlay if provided. Eleven of the group said LOCs would be "somewhat useful" in supporting target nomination tasking, as most felt somewhat confident in the overlay. Twelve of the respondents claimed overlays would be "useful" in maintaining situational awareness. All 14 wanted the ability to toggle on and off the overlay and 12 of them wanted to highlight the areas they wished to overlay. Thirteen (90%) wanted color-coding and 11 (75%) wanted directional reference and mensuration capabilities. Twelve of the 14 felt highlighting areas they wished to see was a good idea.

	Not Useful (1)	(2)	(3)	Somewhat Useful (4)	(5)	(6)	Very Useful (7)	Mean	Median	Mode
Air Force	0	0	1	4	3	0	0	(4.5)	(4)	(4)
Army	2	0	1	1	1	0	1	(3.5)	(3.5)	(1)
Totals	2	0	2	5	4	0	1	(3.9)	(4)	(4)

Table 26 LOC Overlay Value In Searching for Targeting

Area Delimitation

Area delimitation is a technique which considers the topography, vegetation and terrain slope in eliminating areas which selected targets could transverse. For example, if the area delimitation overlay were used, one would eliminate those areas where the slope was too great or too rugged or soft for a particular type of vehicle. Area delimitation may also include consideration of the tactical doctrine associated with a particular target (as operated by a particular military force); certain equipment, for example, may not operate within a specified distance from builtup areas. An area delimitation overlay would depict those portions of an imaged scene where targets of the specified would not be expected to operate.

Ninety percent (13) responded they would use area delimitation overlays, if available, see Table 28. Five IAs felt they would be useful in search, spot, or point target work. All the SMES wanted the ability to toggle the overlay between "on' and "off" states and 13 of the 14 wanted the ability to indicate the specific areas they wished to have delimited.

	Not Useful (1)	(2)	(3)	Somewhat Useful (4)	(5)	(6)	Very Useful (7)	Mean	Median	Mode
Air Force	0	0	1	2	3	2	0	(4.75)	(5)	(5)
Army	0	1	0	0	0	0	5	(6.2)	(7)	(7)
Totals	0	1	1	2	3	2	5	(5.4)	(6.5)	(7)

Table 27 Overlays Value in Searching for Targeting

Change Detection

Change detection is defined as revisiting a previously searched (i. e., imaged and exploited) area and noting the changes made to the previous scene (differences) since the prior coverage was accomplished. Observing the movements of military units and the construction or adaptation of facilities are examples of exploitation tasks which can be expected to benefit from applying change detection comparative analyses.

All respondents have used change detection, see Table 28. All but one felt it "very useful" in search, spot, and point modes. All wanted to toggle it off and on. All of the respondents "valued" their change detection system. The other target search tools were

rated as "very useful" and "very important." The ability to flicker, overlay scenes, and lay them side by side was also considered "useful" or "very useful" by at least nine of the 14 IAs. Overlay scenes, side-by-side scenes and flicker techniques were all rated of equal utility in supporting change detection-based exploitation. Ten or more respondents identified rotation, scaling, alignment, and compass rose/north arrow as "important" for fine-tuning of overlay scenes. The most important tool considered for overlay work was "alignment" (100% wanted). No other overlays were considered useful for target search by 12 of the 14 IAs.

	Not Useful (1)	(2)	(3)	Somewhat Useful (4)	(5)	(6)	Very Useful (7)	Mean	Median	Mode
Air Force	0	0	0	0	1	1	6	(6.6)	(7)	(7)
Army	0	0	0	0	0	2	4	(6.7)	(7)	(7)
Totals	0	0	0	0	1	3	10	(6.6)	(7)	(7)

Table 28 Availability of Change Detection Systems

Flicker *is defined as toggling the past scene against the present scene looking for any difference.*

Overlay *change detection is defined as superimposing a past scene with present scene with the capability of removing [subtracting] one of the scenes from the other to highlight any difference.*

Moving Target Indicator

Moving Target Indicator (MTI) is a system that can detect the movement of vehicles if the vehicles exceed a particular velocity threshold. The MTI information is depicted as dynamic symbology on an IA's monitor. In some systems (e. g., the Joint Surveillance Target Attack Radar System), separate MTI and SAR imagery displays are provided while in others the MTI symbology is overlayed on SAR image. In the ASARS2 system, for example, targets are depicted as highlighted icons of tanks, tracked or wheeled vehicles.

Seventy percent (10 of the 14) of the respondents had not used an MTI system, thus the results of this section are not reliable, see Table 29. The four respondents to this section (100%) said MTI, in the context of the ASARS system, did contribute to mission success, situational awareness, target acquisition, and mission pacing. Three IAs claimed there is little to no change in workload, while the fourth MTI-experienced IA did not respond to this question. Three said MTI combined with ASARS SAR imagery contributed significantly to target location, situational awareness, and target tracking. All four responded they felt using MTI with ASARS imagery "somewhat contributed" to target identification and three said the target displays on the MTI/ASARS format display were "adequate."

	Degrades (1)	(2)	(3)	Contribute Somewhat (4)	(5)	(6)	Contributes Significantly (7)	Mean	Median	Mode
Air Force	0	0	0	0	0	1	0	(6)	(6)	(6)
Army	0	0	0	0	1	2	0	(5.7)	(6)	(6)
Totals	0	0	0	0	1	3	0	(5.8)	(6)	(6)

Table 29 Contribution of MTI and ASARS toward Mission Success

Force-Structure Assessment

Force-Structure Assessment (FSA) is the automated recognition of doctrinal deployment patterns (such as defined defensive missile site patterns). Only 10 analysts answered the questions referring to FSAs, see Table 30. Fifty percent (five of the 10) respondents felt search time would not be improved using FSA.

	Strongly Agree (1)	(2)	(3)	Neither Agree nor Disagree (4)	(5)	(6)	Strongly Disagree (7)	Mean	Median	Mode
Air Force	1	0	0	0	1	0	0	(3)	N/A	N/A
Army	2	0	0	4	0	0	0	(3)	(3)	(4)
Totals	3	0	0	4	1	0	0	(3)	(4)	(4)

Table 30 FSA Will Reduce Search Time Locating Targets

Summary of Aids

The automated tools, rated best to least by the 10 IAs, were: ATR and Change Detection (of equal standing); ATC; and MTI, Area Delimitation, and LOC (closely grouped). There was no consensus whether automated tools would significantly augment the IAs' ability. Two SMEs reported that they "strongly agree," two said they "Disagree," and the rest were evenly spread one each, between they "partially agreed" to "partially disagreed" with this assertion. The eight respondents split evenly on whether they felt confident with the implementation of automated tools. Most (five of the eight) "strongly agreed" they would review automated detections before reporting them and "strongly agreed" they would want to be totally interactive with automated products. Four of the eight "strongly agreed" they would want to review any imagery with or without targets of interest identified on them before releasing.

Reporting Procedures

Different types of product reports are employed (as well as produced) by IAs (based on organizational responsibilities, phase of exploitation, etc.). The following intelligence reports had been used by the given number of IAs (out of a possible 14), see Table 31.

Reports	Air Force	Army	Total
IPIRs	8	6	14
Soft copy Image Responses	6	6	12
Order of Battle	5	2	7
RFI responses	2	4	6
Hard Copy Image Prod	3	2	5
Positional Reports	0	4	4
IIRs	1	3	4
Hot Spots	3	1	4
SUPIRS	3	0	3
Free Form Analytical Rpt.	0	2	2
Voice Report	2	0	2
SIDS	1	1	2
Target Graphics	0	0	0

Table 31 Intelligence Reports Used By the IAs

All 14 analysts have generated IPIRs; 12 used soft copy imagery products; seven used Order of Battle; six RFI responses; five used hard copy imagery products, and four had experience in employing positional reports, IIRs, and Hot Spot reports. The following products are ranked in order of preference, first to last: IPIRs, soft copy image products, Order of Battle, RFI responses, hard copy imagery products, positional reports, IIRs, Hot Spot reports, SUPIRS, free form analytical reports, voice reports, secondary imagery dissemination, and target graphics last. The group was fairly evenly divided on whether the current reporting format tools are easy to use, but they "strongly agree" that initiating new reports is time consuming. There was no consensus on whether the reporting formats are adequate for all types of exploitation (Table 32).

	Strongly Agree (1)	(2)	(3)	Neither Agree nor Disagree (4)	(5)	(6)	Strongly Disagree (7)	Mean	Median	Mode
Air Force	1	3	1	1	1	1	0	(3.1)	(2.5)	(2)
Army	1	1	1	0	1	0	2	(4.2)	(4)	(7)
Totals	2	4	2	1	2	1	2	(3.6)	(3)	(2)

Table 32 Adequate Reporting Formats

Automated Production Tools

Five of the 10 IAs reported spending as much time on preparing reports as they did on exploitation, three reported spending about the same time on both, and the other two said they spent less. Two stated the tools used to produce intelligence products were "adequate," while three "neither agreed nor disagreed." The rest were divided on whether they had adequate tools to support the production of reports. Four reported that they "neither agreed nor disagreed" whether more fonts or aids were needed in their tool kit. Two thirds (six out of nine) "strongly agreed" they wanted more automated fields, such as: titling, geo-coordinates, and other target-relative data. Five of them "strongly agreed" and three "agreed" that they wanted command overlays or friskets that could be applied automatically. Seven of the 12 respondents "strongly agreed" and two others "agreed," that they have their work reviewed (for quality assurance purposes) by at least one other IA before release. All 10 respondents either "agreed" or "strongly agreed" their mission supervisor is responsible for quality control.

User Aid Ratings

The respondents rated the tools listed below with respect to their utility with search and spotlight imaging modes using the following rating scale: 1 - use always, 2- moderate usage, 3- occasional usage, 4- seldom used, 5- never used, 6- don't have, and 7- would use if had. Not all respondents rated all the tools. The decimals relate to the distance between the two whole ratings given above.

Working Tools	Air Force	Army	Mean	Median	Mode
Intel. Report Format	1,2,1	1,1,1,1	1.1	1	1
Maps	3,2,4,2,1	1,1,2,1,1	1.8	1.5	1
Imagery Data Bases	1,2,1	7,1,7,1,1	2.6	1	1
Mission Overlays	6,2,6,1	1,7,2,1,1	2.8	2	1
Target Folders	2,4,2,1,5,1	5,1,5,1,7	3.1	2	1
Imagery Keys	2,1,3,2,4	7,2,3,1,7	3.2	2.5	2
Imagery Head	1,1,1,3	4,7,7	3.4	3	1
Target Graphics	2,3,3	6,2,5,7	4.0	3	N/A
SIGINT Reports	6,3,4	5,7,7,1,4	4.3	4.5	N/A
Elec. OOB Data Base	3,5,7,2,4,3	7,1,7,7	4.6	4.5	7
LOC Overlays	4,4,5,2	7,7,4	4.7	4	4
Comparative Cover	2,5,2,3,2	7,7,7,7,7	4.9	6	7
ATC/ATR	3,5,2,2	7,7,7,7,7	5.2	7	7

Table 33 Search Mode

Working Tools	Air Force	Army	Mean	Median	Mode
Intel Report Formats	1,5,2	1,1,1,1	1.3	1	1
Maps	4,3,2,4	2,1,3,1,1	2.3	2	1
Imagery Data Base	1,1,2,1	7,1,7,7,1,1	2.9	1	1
Imagery Keys	1,1,1,1,2,2	7,2,3,7,1,7	2.9	2	1
Imagery Head	1,1,1,1	4,7,7	3.3	1	1
Target Folders	2,2,4,2,1,5	5,1,4,7,1	3.4	2	N/A
Mission Overlays	5,6,2,6	1,7,4,1,1	3.7	4	1
SIGINT Reports	5,6,3,4	5,7,4,1,4	4.3	4	4
Comparative Cover	1,3,5,2,1,2	7,7,7,7,7	4.6	5	7
ATC/ATR	2,3,5,2	7,7,7,7	5.0	6	7
Target Graphics	5,2,3,3,6,6	6,2,4,7,7	5.0	5	6
LOC Overlays	5,5,4,5	7,7,4	5.3	5	5
Elec. OOB Data Base	3,7,5,7,3,4	7,7,7,7	5.7	7	7

Table 34 Spot Mode

The ratings of the usefulness of the "exploiting tools" varied drastically between the Army and the Air Force respondent groups. The Army responses indicated that in both search and in spot mode all six would use: ATC/ATR, comparative cover, electronic OOB database, and imagery header. Most of them (5 of the 6) always used, both in the search and in spot mode: imagery databases, intelligence report formats, and maps. There were four who seldom used or never used SIGINT and target folders, in search or in spot mode; and four who use or would use the mission overlay tool in search and in spot mode. The rest of the Army analysts reflected no consensus on the remainder of the user aids.

Five of the six Air Force respondents, for search and spot mode, rated the ATC/ATR and the LOC, as "moderate" to "never use." In search mode, comparative cover was also rated as "moderate" to "never use" by five of the Air Force respondents. The only real consensus for user aids was five out of the six Air Force respondents stated, that in the spot mode, they "always used" imagery database, imagery header, and imagery keys. Thirteen of the 14 Army and Air Force respondents felt their user aid tools were sufficient.

Waterfall Plus

Rapidly expanding operational needs, brought on by increased focus on situational awareness in the "battlespace" have levied increased requirements on intelligence operations. Providing detailed and accurate data to the warfighter in a timely fashion is one of the major areas for improvement. Desert Storm after action reports highlighted the need for more refined targeting solutions for smart munitions and the ability to place attack aircraft on mobile relocatable targets. Concept demonstration programs including

Real-time Targeting Systems (RTS) and Real-Time Information to the Cockpit (RTIC) have provided strong support to the idea of providing timely imagery, together with supporting gelocation data, the attacking aircraft. Waterfall Plus (WF+) was the first system to directly address these concepts. "Goldpan" flight demonstrations 95-97 focused on rapid target nomination and real-time target cue dissemination operations, and the analysts were asked to submit additional comments related directly on WF+.

Background

All WF+ operators were trained on site. The training course was basically one day in duration. The analysts received "hands on" experience in operating the WF+ workstation prior to accomplishing operational mission exploitation. Analysts were trained with seeded imagery (imagery with simulated mobile Transporter-Erector-Launchers (TELs), digitized into the image). During the "live" missions, analysts received direct downlinked ASARS2 imagery. The IAs performed detailed searches for the TELs. Secondary MASINT sources provided cueing data that a missile launch had occurred. The WF+ retrieved a reference image based on the location of the cue data. The U-2 was then directly tasked to take a detailed spot within 45 seconds of sensor cueing. The analysts then looked for change detection or radar observables and chipped out (automated cut and paste) the target of interest, then transmitted these chips to attacking aircraft. The following survey results are directed toward these operations.

Related Operations

The questionnaire given to the four IAs at Beale AFB had a section relating to WF+ operations. Following are their responses.

The four IAs "agree" that WF+ improved their ability to perform more rapid interpretion. They "agree" it did not increase their accuracy and they felt confident they could detect MTL/TELs 60-75% of the time. Two of the four said they could learn to operate the WF+ system without formal training and all "strongly agreed" their training on the system (consisting of 50-75 % OJT) had been adequate. Only two of the four trained using the training syllabus, but all four reported finding the training syllabus very helpful. All "strongly agreed" that a "schoolhouse" background in radar systems and collection tasking was "useful" and all "strongly agreed" they feel confident doing TEL identification.

Three of the four felt running mock missions was the most important part of their OJT, but they had no idea where to look for their targets. One respondent suggested that initiating the WF+ workstation prior to starting the exercise would save time and another suggested that a Zoom capability would be helpful. All four reported that they found the system to be "user friendly" and all also reported that it had taken four to eight hours of hands on training to learn to confidently operate the WF+ system. The group of four was evenly divided on whether they would use a user manual or whether it would be helpful, and whether they felt that a "help" key might be somewhat helpful.

All respondents used the standard configuration while in the general search and in focused examination mode. All four responded some of the settings or functions could be automated and that saving their personally preferred workstation configurations would

save time. The four thought the arrangement which had been provided was effective for most but not all conditions, i.e. exploitation of fixed or permanent targets. The settings/functions were thought to be generally good for search, but not for spot. The quality of the display was generally (three out of the four IAs) thought to be not good for search or focused examination. The ability to re-task search targets directly from WF+ was reported to enhance timeliness.

Zoom magnification was rated as a needed operation. Two IAs said zoom magnification should be greater than 1:1. Three of the four reported zoom should be manually controlled, while all said it should be either manually or automatically controlled. All wanted to control the size and area of the chip. All four reported needing more memory in both the chipping and WF+ windows.

Three of the four respondents felt the mensuration tools were not accurate enough for first phase or second phase exploitation. There was an even split between the IAs as to whether a tool was needed to calculate range and bearing. All "agreed" or "strongly agreed" that mouse control was the best solution for IA operations and that its sensitivity was good, but they would rather adjust it themselves. All rejected the suggestion of using a keyboard, track-ball, or tool-bar over a mouse for control. One rejected the pull-down window concept while the other three "neither agreed nor disagreed" with the idea. All "strongly disagreed" with using a mixture of all the control tools for the WF+ functions.

Three of the four IAs felt a split screen function and a compass-rose or north arrow, would be helpful. All reported the ability to fuse imagery and SIGINT information would be helpful in both search and track identification. All said that an imagery rotatation capability and a monitor adjust/rotate capability would be "beneficial," and they "strongly agreed" that the ability to retain/store images would be desirable. (The current system has all the imagery deleted from the memory and can not be recalled until mission playback.)

The four felt the ability to disseminate WF+ intelligent reports is not important. There was no agreement among the four as to whether the WF+, in its current configuration, was an excellent exploitation tool. All felt it was an excellent primary search and ID tool and that it should be coupled with the ability to send image frames or chips to other exploitation terminals/stations to provide a more viable configuration.

Exploitation Systems Functions

The analysts were requested to evaluate various tools of the trade in both search and spot modes of exploitation. The consensus of 12 IAs opinions was that the primary tools for exploitation should be mensuration, zoom or magnification, and coordinate determination. It is interesting to note, the IAs rated both rotation and contrast adjustment slightly higher in importance during spot mode than in search and they rated coordinate determination slightly lower in spot mode.

The respondents rated the tools listed below: (4- must have, 3- nice to have, 2- do not need, and 1- no opinion)[5]. Not all the IAs rated each of the tools.

Task	Air Force	Army	Mean	Median	Mode	Total Score
Magnification/Zoom	4,4,4,4,4,4,4,4	4,4,4,4,4,4,4	4.0	4.0	4	56
Mensuration	4,4,4,4,4,4,4,4	4,4,4,4,4,4,4	4.0	4.0	4	56
Coord Determination	4,4,4,3,4,4	4,4,4,4,4,2	3.8	4.0	4	45
Lat./Long.	4,4,4,4,4	4,4,3,4,4	3.9	4.0	4	39
UTM	3,2,3,4	4,4,4,3,4	3.2	4.0	4	32
WGS	3,1,3,4	2,4,4,4	3.1	3.5	4	25
Pixel Sharpening	4,4,3,4,3,3,4	3,4,2,4,3,2	3.3	4.0	4	43
Change Detection	4,3,4,4,3,4	3,3,4,3,3,4	3.5	3.5	3/4	42
Contrast	4,4,4,4,2,4	4,4,1,4,3,4	3.5	4.0	4	42
Annotation	4,4,4,3,3,4	2,4,4,4,3	3.5	4.0	4	39
Brightness	4,4,4,2,4,4	4,4,1,4,3	3.5	4.0	4	38
On Line Image Storage	4,4,4,4,3	4,4,3,2,1,4	3.4	4.0	4	37
Gray Scale	4,3,4,4,2	4,3,4,3,2,4	3.4	4.0	4	37
Image Chipping Tool	4,3,4,4	4,3,4,4,1,4	3.5	4.0	4	35
Mission Overview Dis.	4,3,4,3,2	3,3,3,4,4,2	3.2	3.0	3	35
Auto Target Cueing	4,1,4,1,2,4	3,3,4,3,4	3.0	3.0	4	33
File/Image Transfer	4,3,4,3	4,3,4,3,1,4	3.3	3.5	4	33
Dynamic Tasking	2,4,2	4,4,4,4,4,4	3.6	4.0	4	32
Imagery Header	4,4	4,4,4,2,4,4	3.8	4.0	4	30
Rotation	3,3,3	4,3,4,4,2,4	3.3	3.0	3/4	30
Waterfall Image Display	4,3,3,4	4,3,1,2,4,1	2.9	3.0	4	29
Scene Comparison	4,3,4,1	3,3,3,4,2,3	2.9	3.0	3	29
Edge Sharpening	4,4	4,4,3,4,1,4	3.5	4.0	4	28
Imagery Keys online	3,3,4	4,3,3,3,2,3	3.1	3.0	3	28
Edge Detection	4,3,1	4,3,3,4,1,4	3.0	3.0	4	27
LOC Overlays	4,3,1,4	3,3,3,3,1,2	2.7	3.0	3	27
Auto Target Rocog.	3,3,3,1,2	3,3,4,3,3	2.8	3.0	3	28
SIGINT/Imagery Corr.	4,3,4,2	3,3,1,2,3	2.8	2.0	2	25
System Coor.Acc. Data	4,4,2	3,4,1,2,3	2.9	3.0	4	23
Range & Bearing Tool	3,3,2	4,3,2,2,3	2.7	3.0	3	22
Target Nomination	2,1	4,2,1,2,1	1.9	2.0	1/2	13
Declutter	1,1,1,1,1	1,2,1,4	1.4	1.0	1	13

Table 35 General Search Task

[5] The "Total Score" considers the total number of IAs responding plus a value for their response rating. The total scores were computed using: 4 points for every rating of 4, 3 points for a 3, 2 for a 2, and 1 for a 1.

Task	Air Force	Army	Mean	Median	Mode	Total Score
Contrast	4,4,4,4,4,4,	4,4,4,4,4	4.0	4.0	4	44
Mensuration	4,4,4,4,4,4	4,4,4,4,4	4.0	4.0	4	44
Rotation	4,4,4,4,4,3	4,4,4,4,4	3.9	4.0	4	43
Brightness	4,3,4,4,4	4,4,4,4,3	3.8	4.0	4	38
Image Chipping Tool	4,4,4,4	4,4,4,4,4	4.0	4.0	4	36
Magnification/Zoom	4,4,4,4	4,4,4,4,4	4.0	4.0	4	36
Coord. Determination	4,2,3,4,4	4,4,4,4,4	3.5	4.0	4	35
Lat/Long	4,4,4	4,4,4,4,4	4.0	4.0	4	32
UTM	4,4,	4,4,4,4,4	4.0	4.0	4	28
WGS	3	4,4,3,4	3.6	4.0	4	18
Change Detection	3,3,3,4,4	3,4,3,3,4	3.4	3.0	3	34
Edge Detection	4,4,2,4,4	4,3,4,4	3.6	4.0	4	32
Annotation	4,3,3	4,4,4,4,3	3.62	4.0	4	29
File/Image Transfer	3,3,3,4	3,4,4,4	3.5	3.5	3,4	28
Gray Scale	4,3,3,4	3,4,3,4	3.5	3.5	3,4	27
Online Image Storage	3,4,3,3	2,4,3,4	3.25	3.0	3	26
Imagery Keys Online	3,4,3,3	2,4,3,4	3.25	3.0	3	26
Imagery Header	4	4,14,4,4	3.5	4.0	4	21
Scene Comparison	4,3	4,3,3,4	3.5	3.5	3,4	21
Auto Target Cueing	2,2,2	3,4,3,4	2.85	3.0	2	20
Auto Target Recog'n	2,2,2	3,4,4,3	2.85	3.0	2	20
Declutter	3,2,2	3,4,3,4	2.85	3.0	3	20
Range & Bearing Tool	4,2,3,2	2,3,4	2.8	3.0	2	20
Dynamic Tasking	4	4,3,4,4	3.8	4.0	4	19
Edge Sharpening	4	4,2,4,4	3.6	4.0	4	18
Mission Overview Dis.	2,2	4,4,2,4	3.0	3.0	2,4	18
Pixel Sharpening	4,2,3	2,3,4	3.0	3.0	4,3,2	18
SIGINT/Imagery Corr.	2,2,3,2	4,3,2	2.57	2.0	2	18
System Coord Acc. Data	2	2,4,4	3.0	3.0	2,4	12
Waterfall Image Disp.	1,4,1	2,1,3	2.4	1.5	1	12
Target Nomination	4	2,1,1	2.0	1.5	1	8

Table 36 Required Tools for Focused/Spot Exploitation

In responding to the "general search tasking" section of the questionnaire, the majority of the SMEs said they must have the following function tools: annotation, brightness, contrast, coordinate determination in Lat./Long., dynamic tasking, edge sharpening, imagery header, magnification/zoom, and mensuration. All except one or two felt the following functions were, at least, nice to have or better for "general search tasking": auto target cueing, auto target recognition, change detection, UTM coordinate determination, edge detection, imagery keys, gray scale, file/image transfer, image chipping tool, on line image storage/retention, mission overview, pixel sharpening, range

and bearing, recognition keys, rotation, scene comparison, SIGINT/imagery correlator, and system coordinate accuracy data. With regard to "focused spot exploitation," the majority of the respondents indicated that they must have: annotation, brightness, contrast, coordinate determination in Lat./Long, UTM, WGS mapping systems, dynamic tasking, edge detection, edge sharpening, imagery header, gray scale, file/image transfer, imagery chipping tool, magnification/zoom, mensuration, mission overview display, pixel sharpening, range and bearing, rotation, and scene comparison. (None of the IAs suggested any functions which were not already listed for their assessment.)

Seven of the nine analysts preferred to use function keys/key strokes or the mouse to interface all the exploitation functions to conduct a "general search." The two dissenting analysts preferred either a pull down menu or a tool bar. In a "focused spot mode" all analysts preferred using either function keys/key strokes or a mouse.

Preferred User Interface Tools

The majority of the analysts surveyed preferred the mouse as the primary interface tool for the control of the workstation image exploitation or manipulation functions. Standard keyboard input was rated as the number two choice for data control or input. Table 37 reflects the users' interface preference. The numbers in the shaded areas refer to interface tools/methods, while the numbers in the unshaded areas are the number of analysts that rated that item/tool as their preferred interface. Not all of the analysts rated all of the tools. Of interest, the majority of the analysts preferred only traditional computer interface tools such as the mouse and keyboard entry. None of the analysts showed any desire to explore the possibility of voice control or automated functions. The negative response to non-traditional methods could be correlated to lack of experience with modern technologies or to the (perceived) immature development and implementation of such tools.

	Keys	Mouse	Tool Bar	Pull Down Menu	Icons	Voice	Push Button	Automated	Mean	Median	Mode
Annotation tools	3	7	1	1	0	0	0	0	**2**	**2**	**2**
Auto Target Cue	2	4	1	1	1	0	1	0	**2.9**	**2**	**2**
Auto Target Recog.	2	4	0	2	1	0	1	0	**3**	**2**	**2**
Brightness	2	6	3	1	0	0	0	0	**2.25**	**2**	**2**
Change Detection	2	7	1	0	0	0	0	0	**1.9**	**2**	**2**
Contrast	2	6	3	1	0	0	0	0	**2.25**	**2**	**2**
Coordinates	3	7	1	0	0	0	1	0	**1.8**	**2**	**2**
Lat/Long	3	5	0	1	0	0	1	0	**2.4**	**2**	**2**
UTM	3	5	0	1	0	0	1	0	**2.4**	**2**	**2**
WGS	3	3	0	1	0	0	0	0	**1.9**	**3**	**n/a**
Declutter	3	3	0	2	0	0	0	0	**2.1**	**3**	**n/a**
Edge Detect	2	6	0	2	0	0	0	0	**2.2**	**2**	**2**
Edge Sharpening	2	3	0	2	0	0	0	0	**2**	**2**	**2**
Imagery Header	2	3	0	3	0	0	0	0	**2.5**	**2**	**n/a**
Image Keys Online	4	4	0	2	0	0	0	0	**2**	**2**	**n/a**
Gray Scale	3	5	1	1	0	0	0	0	**2**	**2**	**2**
File/Image Transfer	4	5	1	2	0	0	0	0	**2.1**	**2**	**2**
Image Chip Tool	2	7	1	1	0	0	0	0	**2.1**	**2**	**2**
Online Image Store	3	4	0	3	0	0	1	0	**2.7**	**2**	**2**
Prod Overlay Frisket	3	2	0	1	0	0	1	0	**2.6**	**4**	**1**
LOC Overlays	3	4	1	1	0	0	1	0	**2.8**	**2**	**2**
Magnify/Zoom	3	6	1	0	0	0	0	0	**1.8**	**2**	**2**
Mensuration	2	8	2	1	0	0	0	0	**2.2**	**2**	**2**
Mission Overview	1	3	2	1	0	0	1	0	**3**	**4.5**	**2**
Pixel Sharpening	2	5	1	0	0	0	0	0	**1.9**	**2**	**2**
Range & Bearing	1	1	1	1	0	0	1	0	**3.4**	**3**	**n/a**
Recognition Keys	1	2	1	1	0	0	1	0	**3.2**	**2.5**	**2**
Rotation	2	5	2	2	0	0	0	0	**2.4**	**2**	**2**
Report Functions	2	1	1	1	0	0	2	0	**3.6**	**3**	**n/a**
Scene Comparison	1	4	1	2	0	0	0	0	**2.5**	**2**	**2**
SIGINT/Image Correlation	1	3	2	2	0	0	0	0	**2.6**	**2.5**	**2**
Waterfall Image	3	4	0	1	0	0	0	0	**1.9**	**2**	**2**

Table 37 Prefered User Interface Tools

Automation of Exploitation Tools

The analysts were asked to determine their preference for either more "manual" control or automated function of exploitation tools, see Table 38. The overall preference was for manual control, with the ability to switch functions on or off, or controlled manipulation of the tools to achieve maximum user satisfaction.

The users only identified three of the 32 suggested functions as possible candidates for automated control - Imagery Header, Online Image Storage, and Waterfall Image Display Speed. Conversely, the majority of the users selected six tools requiring manual control (Brightness Contrast, Coordinate Determination, Dynamic Tasking, Imagery Keys Online, and Target Nomination). Additional tool recommendations for manual control included: Edge Sharpening, Gray Scale, Image Chipping Tool, Magnification/Zoom, Mensuration, Pixel Sharpening, and Rotation.

	Manual	Auto
Annotation tools	8	6
Auto Target Cue	5	6
Auto Target Recog	6	5
Brightness	12	2
Change Detection	7	5
Contrast	12	2
Coordination	6	8
Lat/Long	7	3
UTM	7	2
WGS	5	3
Declutter	2	7
Dynamic Tasking	7	2
Edge Detect	5	2
Edge Sharpening	5	2
Imagery Header	2	6
Image Keys Online	6	2
Gray Scale	8	3
File/Image Trans.	7	5
Image Chip Tool	8	4
On Line Image Storage	3	6
LOC Overlays	4	6
Magnify/Zoom	8	4
Mensuration	9	4
Mission Overview Dis	6	4
Pixel Sharpening	7	3
Product Overlays	5	3
Range & Bearing Tool	3	5
Rotation	8	3
Scene Comparison	5	5
Signit/Image Corr.	4	5
Target Nomination	9	1
Waterfall Image Disp.	3	7

Table 38 Ratings Of Manual Versus Automated Functions

SECTION V

SUMMARY

The intent of this survey was to identify critical areas for improvement of the imagery analyst's mission. The survey's scope was from training and experiencial background, through mission and roles, to individual desires for modern support aides including ATC and ATR.

This initial survey of image analysts' opinions is not a large enough sample to be scientifically valid. The survey also only reflected the opinions of Army and Air Force personnel. There were no National agencies or Navy representatives interviewed or surveyed. Many of the responses from the candidates on the exploitation tools and systems reflect the opinions of <u>only four or fewer</u> analysts. Thus this survey may not truly reflect the opinion of any large group of analysts.

In general, this sampling of IAs represented a strong cross mix of Air Force and Army personnel. The Air Force personnel tended to be junior in rank and had less experience than did their Army counterpart. Overall, the survey revealed the analysts were inexperienced with modern sensors, exploitation systems and tools.

Improvement Suggestions

The immediate needs of the analysts surveyed appear to be met by the established imagery support systems. The majority of the systems are constantly being reviewed and upgraded and most of the existing tools like IPA, 5D, and IESS have active user working groups to support continuous product improvement. However, minor improvements still need to be made with regard to workstation capability and still greater improvements could be made in the human factors arena. Recommendations include:

- The user desires to have total control of the display; this should be individualized (tailored) for optimum performance. These control changes should be captured during log-on and log-off procedures. When the analyst logs-on to another system, his unique configuration should appear. This would breed familiarity with equipment and save precious minutes in system setup procedures.
- IAs all identified the requirement for softcopy, online imagery recognition keys, similar to the former Joint Imagery Interpretation Keys (JINKS).
- The analysts failed to identify a single interactive control mechanization of choice. It is recommended that an extended study (all service study reflecting a larger IA sample size) be conducted to determine the true needs of the user.
- The ability for IAs to complete their mission can be limited by their ability to communicate with outside agencies. Electronic communications appear to be the largest problem.
- The mission planner should be closely involved with the exploitation process.

- User familiarity with ATC/ATR tools should be increased. Increased emphasis should be directed to false alarm rate control so as not to increase the burden on the IAs.
- Scene manipulation such as rotation and magnification should be dynamic and continuous regardless of image size or format. Most ELT software systems have problems dealing with ASARS and SYERS formats.
- Change detection is important. The analysts identified the need for change detection but indicated that flicker is not necessarily the preferred method. This could be traced to the inability for some software packages to flicker full frame ASARS or SYERS.

Experience Level

The experience level of this sample group was limited. Only one of the Air Force analysts reported having more than two years experience on any exploitation system, while the rest had a year or less. The Army group had one senior analyst (more than eight years in the field) and three analysts with three or more year's experience. All the Army people had greater than one year of experience and all had been on operational or exercise deployments, while only four (50%) of the Air Force people had any operational/exercise experience.

If this observation regarding IA experience level generalizes to the greater IA population, then there is cause for concern. Embedded training support, including adaptive tutors, is a technology which may help overcome limited experience. Decision support aids, including softcopy interpreation keys, may also help to compensate for limited experience.

Training

All the respondents were qualified, having attended some basic training course in a formal military training program. All had also received extra OJT training. Four of the 14 had received advanced service training on one or more systems. Still, with only initial training being widely received by the IA community, new systems may not be properly implemented in the field. Numerous times experimental test systems become operational assets. Initial training programs cover all the immediate needs of the user; however follow-up training is often lacking and must be compensated for through OJT. It is recommended that:

- When experimental systems or software are fielded, duplicate systems be delivered to training commands.
- "System of systems" tiger training teams be established to annually train all related programs (this could be conducted via CD-ROM or video training programs using tools such as the Armstrong Laboratories intelligent tutor).
- Annual formal systems training be conducted to prevent the information loss normally encountered with OJT techniques.

Skills

A broad range of skills were represented within even this small group. However, the expertise reflected upon any one system was limited to only a few people and those few had only limited experience on those systems. The Army analysts generally had more experience on the systems than did the Air Force people.

Tools and Aides

In general the IAs are satisfied with the current tool set at their disposal. However, there remain some key shortfalls in the tools and aids arena. Improved functionality control appears to be mandatory. The analysts must have total control of the tools available on the exploitation station. Since there remain multiple analysts operating limited numbers of workstations, each analyst would like the system to retain all the independent user settings (i. e., the retention of individually tailored workstation configuration) upon exit.

All of the analysts surveyed would like to have previously identified targets labeled in their reference window. There is an apparent need to disseminate reference identification keys on each of the terminals.

Human Factors Engineering

In evaluating existing exploitation software, it was apparent that all the various exploitation tools meet most of the IAs minimum requirements. However, little coordination appears to have been accomplished to ensure the method of presentation of the same tools in one system is the same as that used for the same (or similar) tool in any other system, or that the best or most efficient methodology for a system display has been incorporated into any tool instantiation. The advancement towards DCGS compliance or general tool acceptance, increases the need to review these human system interface issues.

Exploitation tools are very similar to word processing systems in that there are unique tools and functions in each package. Word Perfect, Word Star, MS Word, and Works are all word processing systems that basically do the same functions and operations. However, if a user is accustomed to one word processor and is provided access to another, it limits the user's ability to function smoothly until that new system becomes very familiar. Each exploitation tool has one or two features that may be superior to others. If a review of the significant features of each exploitation tool were conducted, where each subject were able to pick and choose the "best of the best" applications and these applications were to be incorporated into a unified system, the end result would almost certainly be a far better, more unified, and more friendly mix of exploitation tools.

SECTION VI

Recommendations

Build New Version HMI

A next version of the exploitation HMI system needs to be forthcoming.

The Survey

An in-depth survey needs to be conducted of the current exploitation tools, using the IAs from all services to evaluate all the current systems and tools. Each analyst should identify the best (or worst) feature of that system and rate each tool within that system. The frequency of use/action needs to be considered along with the changes each analyst suggests. The results should be incorporated into the next-generation exploitation station HMI.

Designing the System

Using the compiled results from the above survey, an HMI system must be designed and built using the best ideas from the best systems. The new system must have the capability to exploit data obtained from all the intelligence processing systems in existence, as the world wide imagery network becomes operational. Local and standard environmental conditions, imagery, and products may be the norm for any facility or station, but world wide interface capabilities and/or support requirements may introduce exacerbating factors and problems into a facility. This would require special techniques and tools not common to that site and would not be available upon demand by the analyst.

Human Factor Engineering

Human factors engineers need to ensure image size, color/icon selection, eye movement, keystrokes, screen size, keyboard and seat height, and other ergonomic and design factors all reflect the best placement and population size percentiles. The exploitation system responses from tool devices such as the mouse, keyboard, and/or voice interface commands must appropriately reflect required response speed, agility, flexibility, utility, and inter-operability between tools/screen displays. It is imperative all these functions operate well together with the IAs. (One of the software tools investigated required the analyst to look off the image to determine size of objects that were being measured. The analyst would mark two points for size determinations and would have to look off to the left for the actual measurement and then reorient back to the image. A reasonable solution would be that the answer appears above the object.)

Time Saving Methods

Incorporated into the new exploitation HMI version must be the ideas expressed by the analysts to conserve time. Better friskets need to be developed to reduce the time analysts devote to creating secondary imagery dissemination (SIDS) products. Automated frisket templates complete with selectable datafields including: command, unit and agency logos, target id, location, name, and Order of Battle would significantly

aid the exploitation process. (Frisket is a standard product overlay for secondary imagery dissemination. Friskets typically identify the submitting organization and key target information such as target name, coordinates, target category, and date.)

The images and setups, pre-set by individual analysts, must be available for recall from any local network on-line screen to facilitate daily/occasional analyst station changes.

Special Recognition Keys

Special on-line recognition keys for certain exploitation mode displays should be developed to assist the IA in analyzing certain targets of interest. Keys that provide a multi-look, multi-view, multi-aspect, and a multi-sensor image of high priority targets need to be examined for inclusion. The capability to enable scaling, rotation, spot magnification, and object placement to match overlay or side-by-side views of objects also should be considered and automated (with override capability).

Phased images will necessitate image set points/coordinates onto which the phased imagery must be co-located for differential measuring. This exploitation technique will require considerable image manipulation and enhancement which may be considered desirable for this new HMI version.

Report Generator

The analysts claim that the time spent to generate a report is as long, if not longer, as the time to do the original analysis. This problem has long been recognized and has been partially addressed before with canned reports generated with blank spots for the analysts to fill in. Enhanced automated message and report generation methodologies need to be addressed. Simple aides like order of battle reporting, automated headers and addressing of reports (highlighted by voice or point command) with multiple connection capability to transmit and exchange data/report communications are also strongly recommended. Some of the tools investigated during the exploitation software analysis had rudimentary OOB reporting tools that enable analysts to select generic naval, aircraft, and ground OOB symbols for reporting. One possible improvement could be the incorporation of specific OOB tools. For instance if analysts were reporting on a Peruvian Naval Base, the standard Peruvian OOB would appear in the reference window. This could aid new analysts by not mis-reporting a Whiskey Class submarine when they only have Collins Class submarines included in the actual force structure. The analysts could also point and click a particular unit (e.g. Mig 31) and the specific number of aircraft at an airfield would appear for inclusion in a semi-automated report.

An in-depth review of the exploitation reports may be warranted.

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GLOSSARY

AF	Air Force
AL	Armstrong Laboratories
ANVIL	Applied Analysis Spectral Analytical Program
AR	Army
ASARS-2	Advanced Synthetic Aperture Radar System for the U-2
ASC	Aeronautical Systems Center
ATARS	Advanced Tactical Airborne Reconnaissance System
ATC	Automatic Target Cueing
ATR	Automatic Target Recognition
CAOC	Combined Air Operations Center
CARS	Contingency Airborne Reconnaissance System
CATIS	Computer Aided Tactical Information System
CIGSS	Common Imagery Ground/Surface System
CIP	Common Imagery Processor
CHBDL	Common High Bandwidth Data Link
COMINT	Communications Intelligence
COTS	Commercial Off The Shelf
CSP	Communications System Processor
5D	Demand Driven Direct Digital Dissemination
DARO	Defense Airborne Reconnaissance Office
DCGS	Distributed Common Ground System
DDPO	Defense Dissemination Program Office
DIEPS	Digital Imagery Exploitation and Production Systems
DGIF	Deployable Ground Intercept Facility
DGS	Deployable Ground Station
DIPS	Digital Imagery Processing Systems
DSAIPT	Defense Sensor and Intelligence Application Program Training

ELINT	Electronic Intelligence
ELT	Electronic Light Table
EO	Electro-Optical
ETRAC	Enhanced Tactical Radar Correlator
FSA	Force Structure Assessment
HCI	Human Computer Interface
HMI	Human Machine Interface
HMMWV	High Mobility Multi-purpose Wheeled Vehicle
HUMINT	Human Intelligence
IA	Image Analyst
IDEX	Image Data Exploitation System
IESS	Imagery Exploitation Support System
IIR	Imagery Interpretation Report
IMINT	Imagery Intelligence
INT	Intelligence
IPA	Image Product Archive
IPIR	Initial Photographic Intelligence Report
IPL	Image Product Library
ISR	Intelligence Reconnaissance and Surveillance
I&W	Indications and Warning
JDISS	Joint Deployable Intelligence Support System
JINKS	Joint Imagery Interpretation Keys
JOG	Joint Operations Graphic
JNC	Joint Navigational Chart
JSIPS	Joint Service Image Processing System
JTF	Joint Task Force

KCOIC	Korea Combined Operations Intelligence Center
LOC	Line of Communications
MAE	Medium Altitude Endurance
MASINT	Measurement and Signals Intelligence
MIES	Mobile Imagery Exploitation System
MIS-U	Mission Intelligence Segment-Upgrade
MSG	Message
MSI	Multi-Spectral Imagery
MTI	Moving Target Indicator
NAIC	National Aerospace Intelligence Command
NDS	National Photographic Intelligence Center Data System
NIIRS	National Imagery Interpretation Rating Scale
NIMA	National Imagery and Mapping Agency
OB	Order of Battle
OJT	On the Job Training
ONC	Operational Navigational Chart
RFI	Request For Information
RIGS	Reconnaissance/Intelligence Ground Systems
RPC	Rapid Positioning Capability
RTIC	Real-Time Information to the Cockpit
RTS	Rapid Targeting System
SAIP	Semi-Automated IMINT Processing
SAR	Synthetic Aperture Radar
SCI	Sensitive Compartmented Information
SIDS	Secondary Imagery Dissemination System

SIGINT	Signals Intelligence
SUPIR	Supplemental Photographic Intelligence Report
SYERS	SENIOR YEAR Electro-Optical Reconnaissance System
S&T	Scientific and Technical
TAD	Temporary Assigned Duty
TEL	Transporter Erector Launcher
TPC	Tactical Pilotage Chart
TS	Top Secret
UAV	Unmanned Aerial Vehicle
USAF	United States Air Force
USIGS	US Imagery and Geospatial Information System
USIS	United States Imagery System
UTM	Universal Transverse Mercator
WF+	Waterfall Plus
WGS	World Geodetic System

APPENDIX A: - CURRENT SYSTEMS AND SOFTWARE

This appendix is intended to provide a general insight into a number of operationally deployed hardware and software systems. The number of differently configured operational systems is a genuine concern. Intelligence operations are unique from other aspects of the warfighting scenarios. The intelligence community for years has created numerous stovepiped or single threaded systems with no interoperability. However, this mind set is rapidly changing. Imagery and intelligence support programs recently have been developing under a new plan to modernize assets in preparation for the 21st Century. This migration path is part of the US Imagery and & Geospatial Information System (USIGS) (formerly United States Imagery Systems USIS 2000) focus to develop integrated intelligence mission elements for the purpose of management, collection, processing, dissemination, library, and exploitation of sensor imagery and data.

The Distributed Common Ground Systems (DCGS) formerly referred to as Common Imagery Ground/Surface System (CIGSS) is an open systems architecture model for this planned migration. The DGCS open architecture allows application of commercial and government standards and products developed in accordance with industry standards. The objective focus of the DGCS is to ensure all ISR platforms' data and imagery can be efficiently received, exploited, and disseminated in usable format to the warfighter.

A.1 Exploitation Software

A.1.1 Ruler

A.1.1.1 Ruler Features:

Ruler supports the missions of many exploitation organizations within the community (1) supporting a diversity of mensuration functions based upon imagery from multiple systems, (2) running on common hardware and common operating systems, and (3) easily operating with other information systems. It performs calculations and produces data on behalf of image analysts, enabling them to produce intelligence products in support of national policy makers and warfighters. When the Rapid Positioning Capability (RPC) becomes available, Ruler, in conjunction with RPC, will provide the capability to do geopositioning, image adjustment/triangulation, and exploitation.

Ruler can be used as a mensuration engine for integration into a softcopy exploitation system or it can be used with its own interface. It is extensible through its object-oriented design and C++ language implementation. A well defined, standardized set of mensuration algorithms and interface programs have been created under the title "Application Programming Interface." Using Ruler Public Interface Specifications, allows other developers to employ Ruler softcopy programs within their exploitation systems to be their computational element; moreover, Ruler has incorporated legacy application software and makes extensive use of COTS software libraries.

A.1.1.2 Ruler Status:

Ruler version 3.0 was released to approximately 56 sites for use as a hardcopy exploitation tool. An additional 18 government organizations have contracted with commercial vendors developing softcopy exploitation tools to access Ruler as a mensuration service. Updated version 7.0 of Ruler is expected by 28 February 1998, version 8.0 is programmed for 28 October, 1998, with deliveries scheduled through November 1999, for Ruler, version 9.0. NIMA has chosen Digital Tool's AutoPLANII as the program management application for Ruler.

A.1.2 Matrix

A.1.2.1 Matrix Features:

MATRIX is a software imagery exploitation application designed to support imagery exploitation requirements such as indications and warnings, target monitoring, and dynamic targeting. This system maximizes the use of COTS products and their capabilities. The primary purpose of MATRIX is to provide software imagery exploitation tools designed to support the imagery analysis process. This is an Electronic Light Table Software Package supporting multi-intelligence and multi-source exploitation. GDE Systems Inc. is the systems integrator.

A.1.2.2 Matrix Status:

The DOD and civilian communities are currently using MATRIX in over one hundred processing and exploitation sites worldwide.

A.1.3 Project ANVIL

A.1.3.1 ANVIL Features:

Project ANVIL (Applied Analysis Spectral Analytical Program) is a software program that is currently part of the ERDAS imagery processing package. ANVIL takes Multi-Spectral imagery, using ERDAS, and goes inside of a pixel to determine the content of the pixel, rather than classifying the whole pixel as with current techniques. Current technology can classify down to as little as 20% of a pixel. This means if the target takes up only 20% of the area of the pixel, one should still be able to identify it. A quick example of the process is as follows. If one has SPOT, Landsat, or a Multi-spectral imagery of an area, and something specific is being sought (i.e. a concrete road) then by going into the image and knowing the spectral properties of many items in the scene (i.e. grass, trees, etc) one can remove all of these objects from the image. If the remaining spectral properties match that of the road, then the road should be there.

A.1.3.2 ANVIL Status:

Bathymetry for NAVSPACECOM. This software provides the capability to determine the water depth for possible landings, under water investigations or other information.

USAFE project. This project is to provide USAFE with an initial Multi-spectral imagery processing capability.

MERIT/AD follow-on. This is a follow-on project sponsored by Defense Dissemination Program Office (DDPO) to take the current process and create a Hyper-spectral processing capability that takes Hyper-spectral imagery data gleaned from new sensor technology and make it appear like Multi-spectral imagery.

A.1.4 Electronic Light Table (ELT)

A.1.4.1 ELT Features:

The Electronic Light Table (ELT) is a COTS image and manipulation system that can be accompanied by text, graphics, video, audio, and other data sources. It is a "user friendly" program with an intuitive user interface display. Advanced mensuration capabilities permit the measurement of minute details within the image and to do close-up analysis using its high-magnification and zooming capability. It uses software packages that utilize the standard UNIX libraries and system calls to interpret, manage, and process 2-dimensional images. It was one of the first imaging systems to meet the National Imagery Transmission Format standards, and uses the latest advances in communication, internet, and database technologies.

A.1.4.2 ELT Status:

The Electronic Light Table is the name given to many COTS programs that all do about the same thing. Each of these COTS programs are competing for the market's named "Best ELT Program" and are still in production. The ELT program produced by Paragon is the software program most used by the US government agencies, but other versions are utilized by commercial industry. These ELT programs are being upgraded as the software and industry demand.

A.1.5 Digital Imagery Exploitation and Production System (DIEPS)

A.1.5.1 DIEPS Features:

The Digital Imagery Exploitation and Production System (DIEPS) is an ELT interface software program designed for government and military customers using POSIX UNIX, X-Windows Motif, and the DoDIIS CSE operating system. It is Motif based with multiple windows and screens. DIEPS is designed for image exploitation using comparative analysis, perspective alteration, continuous zoom, mensuration, interpretation, annotation, managing, and image processing.

A.1.5.2 DIEPS Status:

DIEPS is a commercially produced software program that is used by government and commercial sources. It is still undergoing developmental program changes and is now in its sixth version.

A.2 Current Surface Processor Systems

A.2.1 Enhanced Tactical Radar Correlator (ETRAC)

A.2.1.1 ETRAC Features:

ETRAC is an advanced developmental mobile SAR processor. It receives direct downlinked radar phase history data collected by the ASARS-2 system on board the U2R aircraft. ETRAC converts the radar phase history data into imagery, which is passed to either the IPDS or the Modernized Imagery Exploitation System (MIES) for subsequent exploitation and dissemination of imagery products to consumers. The ETRAC has an organic exploitation capability for stand-alone operations and has a robust communications capability. The ETRAC communications equipment includes the SUCCESS radio, TENCAP communications system processor, STU-III, and digital subscriber voice terminal. The ETRAC was fielded to the 18th Airborne Corps V Corps.

A.2.1.2 ETRAC Status:

At this time, there are two operational ETRACs in the inventory: one is located with the XVIII Airborne Corps at Ft. Bragg, NC; and the other is located with the V Corps at Mainz-Finthern AAS, Germany. In addition, an operational support facility at the contractor's facility provides a software maintenance facility and logistics depot for ETRAC and DoD common SAR processors. Exploitation software baseline is Matrix.

A.2.2 Modernized Imagery Exploitation System (MIES)

A.2.2.1 MIES Features:

The MIES receives national and tactical imagery, along with exploitation tasking, from other systems in the imagery intelligence architecture. The imagery is exploited in either a digital or hardcopy format to produce textual reports and secondary imagery dissemination (SID) products. The products are transmitted to a variety of systems and users. By employing standards such as DIAM 57-5 report formats and the National Imagery Transmission Format (NITF), MIES assures that its products can achieve the broadest dissemination. MIES contains three state of the art digital image exploitation workstations, three hardcopy workstations, a host database, and a Communications System Processor (CSP) for AUTODIN connectivity.

The MIES consists of three primary operational vans: a satellite communications van, a national input segment van, and an exploitation van. Accompanied with its organic support equipment, power generators, and maintenance vans, the MIES is capable of operating anywhere in the world without the need for local support resources.

A.2.2.2 MIES Status:

Three MIES systems are fully operational and supporting the mission of Army users. Upgrades to the baseline are regularly provided to keep pace with new capabilities of

national and tactical sensors and other systems to which the MIES interfaces. In 1994, the Army was directed to build a third MIES to replace a similar system that will be removed from the field. The exploitation software within MIES is ELT 7000.

A.2.3 Contingency Airborne Reconnaissance System (CARS)

A.2.3.1 CARS Features:

The Contingency Airborne Reconnaissance System (CARS) combined with the Deployable Ground Intercept Facility (DGIF) is a multi-intelligence (INT) deployable ground station (DGS). DGS is capable of receiving Electro-Optical (EO), radar, multi-spectral imagery (MSI), moving target indicator (MTI) data, and SIGINT information. CARS primarily supports U-2 missions. In the future CARS may support other surveillance/reconnaissance platforms with the addition of special unit retrofit systems. The ground system is composed of nine segments housed in transportable shelters. Six of the segments are associated with imagery intelligence collection, processing, exploitation, and dissemination. One segment is associated with the Senior Ruby sensor and two are associated with the Senior Spear sensor.

A.2.3.2 CARS Status:

There are two complete Deployable Ground Stations (DGS) within CARS, one at Langley AFB, VA., and the other at Beale AFB, CA. The CARS DGS can be located in a garrison or deployed to the rear echelon of an area of interest as a fully operational multi-INT reconnaissance system.

Over the next few years this system will be modified significantly with the common imagery processors and the commercial common exploitation workstations, running ViTEC ELT, to handle multiple imagery formats and sensor improvements to be in compliance with DCGS migration path. In addition to CARS, the Air Force supports similar facilities including (KCOIC) and the CARS Mission Intelligence Segment Upgrade (MIS-U). Current CARS softcopy imagery architecture contains proprietary elements of image format, process, and connectivity. This proprietary element will be eliminated with the insertion of COTS technology. This step migration is underway currently and will be completed at KCOIC by 1 Oct 1997. The CARS upgrade will follow within the Flight Test Facility at Palmdale, which will be the primary integration and test platform.

A.2.4 Joint Services Image Processing System (JSIPS)

A.2.4.1 JSIPS Features:

JSIPS is a joint USAF, US Navy (USN), and US Marine Corp (USMC) program to develop a common ground station capable of receiving, processing, exploiting, and disseminating imagery intelligence products collected by national, theater, and selected tactical reconnaissance assets. The USAF will use the system to process national imagery in support of the Air Operations Center. The USMC will use JSIPS to support their national imagery requirements and process/exploit Advanced Tactical Air Reconnaissance Systems (ATARS) imagery via the Tactical Exploitation Group (TEG).

The USN will employ a shipboard JSIPS-N system to support national imagery needs and to process ATARS imagery. JSIPS has a rugged construction, which enables it to be installed in 10-foot or 20-foot shelters and on-board aircraft carriers for rapid global deployment via air, road, rail, and sea.

A.2.4.2 JSIPS Status:

The Marine Corps is currently operating JSIPS at Camp Pendleton, California. Two production systems are being fabricated for the USAF to be used by the 9th Air Force, Shaw AFB, South Carolina, which is currently undergoing training, and at HQ 12th Air Force, Davis-Monthan AFB, Arizona. The FY98 funding for this program is provided through the Central Intelligence Office and is expected to cover the replacement of secondary imagery IPA or the procurement and installation of the SCI IPL used as both internal file saver and external library. Exploitation software varies by service. The JSIPS-N uses Matrix whereas the USAF uses ViTEC ELT.

A.2.5 JSIPS-N (PTW)

A.2.5.1 JSIPS-N Features:

The U.S. Air Force (ESC/ICI), under the sponsorship of the Program Executive Officer, Cruise Missiles Project and Unmanned Aerial Vehicles Joint Project, has developed a shipboard version of the Joint Service Imagery Processing System (JSIPS) Tactical Input Segment (TIS) for the Navy. The TIS is the digital imagery interface between the airborne sensor and the surface exploitation workstation and is an integral part of the Navy JSIPS (JSIPS-N).

The JSIPS-N is the shipboard variant of the JSIPS and has the capability to receive, process, exploit, store, and disseminate imagery-based display products, and reports based on multi-source data assimilated from national and tactical sensors. The primary purpose of the JSIPS-N is to increase the independence of seaborne Battle Group tactical and strike aviators, naval fire support, expeditionary force planners, and support the employment philosophy of autonomous weapon systems. The JSIPS-N is also to receive national imagery data from tactical reconnaissance, unmanned aerial vehicles, ground stations, and other sources of battle damage assessment and intelligence exploitation locations.

A.2.5.2 JSIPS-N Status:

A major upgrade to the production TIS is planned with the goal of reducing the footprint of the Engineering Development Model while increasing the number of sensor types capable of being processed by the system. Central to this upgrade is the Common Imagery Processor (CIP), a Defense Airborne Reconnaissance Office (DARO) initiative, which will insure compliance with the DCGS architecture. A color Screening Workstation with rudimentary exploitation capabilities and a non-interruptible Power Source will also be added via this upgrade. Commercial-Off-The-Shelf (COTS) equipment will be used where possible to reduce proprietary hardware, software and firmware.

Input to the TIS will be either by data link, through the Common High Bandwidth Data Link - Shipboard Terminal (CHBDL-ST), or by Mission Tape Cassette Recorder (TCR), one of two TCRs contained within the TIS. The TIS will output processed imagery in NITF 2.0 format to a Strike Planning Archive (SPA) where it will be stored for later retrieval and exploitation on other components of the JSIPS-N.

The Air Force, as the executive agency, will acquire a minimum of twenty-seven (27) TIS units over a period of four years, commencing in Fiscal Year 1998, for use by the Navy. The vehicle for this acquisition is to be the Recce/Intel Ground Systems (R/IGS) Products and Services contract. Twelve units are planned for installation aboard aircraft carriers, 12 aboard amphibious assault ships, and three units at shore sites as these systems become available. Funding support for this program will continue through FY2001.

A.2.6 USAFE Digital Imagery Processing System (DIPS)

A.2.6.1 Digital Imagery Processing System Features:

DIPS provides unclassified softcopy exploitation and hardcopy print production of National and Eagle Visions Commercial Imagery Segment System of broad area imagery. DIPS is moving toward a multi-commercial satellite configuration. The system now processes very large unclassified files and single SPOT satellite imagery of 60-km by 60-km size. DIPS also supports the classified intelligence needs of six operational support squadrons of the USAF.

A.2.6.2 DIPS Status:

The DIPS program is in the process of upgrading its workstations, its servers, and its LAN Infrastructure. It is an objective system proposed to interface with the SPOT, Landsat, Radarsat, Satcom, the commercial satellite systems, many of their dissemination elements, and the Image Product Archive (IPA) in FY98. Funding for this program is projected through FY2003.

A.2.7 Tactical Exploitation Group (TEG)

A.2.7.1 TEG Features:

The TEG, a Marine Expeditionary Force (MEF) asset, consists of a Tactical Imagery Processing System (TIPS), a Tactical Exploitation System (TEXS), and a Tactical Datalink System (TDLS). These subsystems will be deployed in two or three S-788 shelters mounted on High Mobility Multipurpose Wheeled Vehicles (HMMWVs) towing trailers (as required). The TIPS, developed on the commercially based MVS, will process and screen ATARS imagery received from mission tapes or datalink. The TEXS, a modified Intelligence Analysis System (IAS), will perform imagery exploitation on selected target imagery transmitted from the TIPS. Using its six workstations, located in an adjacent soft shelter, the TEXS will disseminate reconnaissance reports and exploited secondary imagery to the MEF IAS and/or subordinate IASs and the Marine Corps Imagery Support Unit (MCISU) via digital tactical backbone communication systems.

A.2.7.2 TEG Status:

The first prototype TEG system was delivered to the Marines in July 1996. By the year 1998 three operational systems are programmed.

A.2.8 Eagle Vision (RV) and Eagle Vision II

A.2.8.1 Eagle Vision Features:

Eagle Vision is a COTS-based deployable ground station, which receives and processes commercial satellite imagery for use in mission planning. The system provides theater commanders current mission planning imagery in a timely fashion. Receipt and processing of the data in the field eliminates the long delays previously encountered with CONUS based processing and makes Eagle Vision a more responsive asset. The Arc Digital Raster Imagery (ADRI) produced by Eagle Vision is entirely unclassified, which makes it particularly well suited for use in coalition warfare. In peacetime, Eagle Vision can be used to update archived data, or to fill gaps in the existing data. The system also provides panchromatic SPOT imagery in a standard commercial format (SPOT Level 1A) for a variety of other uses.

A.2.8.2 Eagle Vision Status:

The Eagle Vision deployable ground station became operational at USAFE Ramstein Germany with SPOT capability. Other systems are currently being explored as possible candidate commercial sources such as: LANDSAT, RADARSAT, and others. A second operational system is to be procured as Eagle Vision II.

A.2.9 National Eagle

A.2.9.1 National Eagle Features:

National Eagle is a C-130 deployable Radarsat/Landsat/SPOT imagery downlink that processes the imagery that it receives into the DMA standard formats. It is currently in operation at Ramstein AB, GE. National Eagle expands on the imagery-processing segment of Eagle Vision. Under National Eagle, the Eagle Vision processing software/hardware will be modified to accept national imagery and develop prototype image that mosaics software permitting users in the field to produce their own specialized three-dimensional display products. The mosaics are currently produced by contractor technicians in CONUS and shipped overseas which usually takes weeks. The products are currently being used for mission planning and rehearsal at Aviano AB, Vincenza, and by the 1st Armored Division in Tuzla, giving the user in the field the capability to produce his own mission planning products, which reduces lead time and reduces the communication load.

A.2.9.2 National Eagle Status:

The National Eagle imagery processing system was delivered in May 1997 at the Space Warfare Center for operational use. It is now supporting the ICS exercise, Project Sandstorm, at MacDill AFB, FL.

APPENDIX B - DISTRIBUTED COMMON GROUND SYSTEMS (DCGS)

B.1 THE DCGS FAMILY OF SYSTEMS

DCGS, formerly referred to as the Common Imagery Ground/Surface System (CIGSS), is an open systems architecture model for planned migration. DCGS is a family of image processing and exploitation systems that can accept unprocessed or processed (e.g., from sensor platforms with on-board processing) data from electronic or tape media sources, and derive imagery and imagery products from that data for military intelligence and operations. Some DCGS missions may also require archiving and disseminating unexploited imagery. The DCGS operates on data received from any of the EO, IR, SAR, and MSI airborne sensors used by the military forces and national agencies.

B.1.1 The DCGS Collection Chain

EO, IR, SAR, and MSI sensors collect imagery from tactical and commercial sources. The imagery, in the form of multiplexed data streams or analog video, is unique to each sensor technology. Data may be downlinked directly to a collocated receive element, captured on tape recorders at a link receiver, relayed through a satellite or aircraft to fixed or forward deployed ground stations, or received on magnetic tape from reconnaissance aircraft upon completion of a mission. The DCGS processes the received data into analyst-exploitable visual images; provides the facilities and tools for data fusion and exploitation; archives the imagery and imagery products generated for military and intelligence operations; and distributes annotated images and image-derived intelligence products to local and remote military users via electronic and tape media means.

B.1.2 DCGS Processing

The Common Image Processor (CIP) reads and processes the incoming data. Still image processing at the CIP includes making the radiometric and geometric corrections needed to prepare an exploitable image. Video is normally fed through the CIP for real-time display to enable interactive platform or sensor control and may be stored for subsequent editing and film clip generation or frame extraction. SAR imagery requires intensive processing within the CIP to provide an exploitable image. Among the image forming radar algorithms are: single patch and sub-frame processing in polar format; overlapped sub-aperture; planar sub-array; range migration; chirp scaling; range-doppler; and back projection. The selection of these algorithms is made within the CIP.

B.1.3 DCGS Mission

Each DCGS is tailored to specific missions; consequently, there are variations in the physical configurations, support software, operating, and logistics requirements among CIGSS compliant systems. Some DCGS' will be mounted in deployable shelters, others may be installed in combat vehicles such as HMMWV, some will be rack mounted at fixed sites, others will be installed on board ships. All DCGS systems will be interoperable via the tactical, strategic, physical, and commercial communications

allocated to the using Service (during peacetime or in-garrison) and to the JTF Commander during crisis and wartime deployments.

B.1.4 DCGS Products

The DCGS will provide deployed commanders with detailed, near-real-time information on enemy forces for targeting and mission planning. Through the remote access capabilities in DCGS, a deployed Joint Task Force (JTF) commander will be able to query, browse, download, and utilize reconnaissance information from any other DCGS within the theater. The DCGS will be globally deployable using a variety of inter-theater lift/mobility assets. To accommodate tactical movements from remote areas, all components will be deployable within C130 aircraft. All deployable DCGS components can be interchanged to facilitate field tailoring and support JTF missions. Initially this requirement for interchangeability will apply to the capability of internet workstations and major subsegments. As DCGS and computer technology evolve, it may be prudent to specify common components, instead of interoperable components, to ensure the maximum flexibility for deployed commanders.

APPENDIX C - EXPLOITATION TOOL REVIEW

An independent review of current imagery exploitation tools was conducted. The review centered on tool functionality to determine the best possible exploitation product. The premise is that IDEX II is the top of the line exploitation system and other tools need to emulate the IDEX functionality. IDEX was developed in the mid-1980s to support national imagery exploitation. IDEX is a fully integrated dual monitor workstation controlled by a large mainframe with direct links into national databases. IDEX is hosted primarily at national level agencies like the Central Intelligence Agency (CIA) , and the Defense Intelligence Agency (DIA); at critical scientific and technical components like the National Aerospace Intelligence Center (NAIC), and within joint service commands like the Joint Analysis Center (JAC) Molesworth, and Joint Intelligence Center Pacific (JICPAC).

This review focused on softcopy exploitation tools that are currently fielded and in use by operational commands. These included: MATRIX, Vitec Electronic Light Table (ELT), Digital Imagery Exploitation and Production System (DIEPS), Waterfall Plus, and Paragon's Electronic Light Table (ELT). The review reveals that none of the 58 tools are identical either to IDEX or to each other. Each tool reviewed did have most of the common tools like zoom, magnification, contrast, brightness. Most of the products offered a unique set of applications. All exploitation products were considered adequate for both tactical and national imagery exploitation tasks. The most notable differences were in the graphical user interfaces (GUI); however, these were not substantial differences. Some tools are not as intuitive and require more training than others. Additionally, not all of the exploitation packages incorporate the same functionality. The Table C1 identifies common exploitation functions and those suites that have those functions. The blue circles indicate an average application and the function is suitable for most analyst applications, a half blue circle indicates the function is below the average application standard, a green circle is for a superior application.

C.1 MATRIX (Version 4.0)

MATRIX is widely used within Army and Navy exploitation systems. MATRIX is well received within the services, even though the GUIís are not the most "user-friendly." MATRIX software is the only deployed tool that includes a capability to exploit multi-spectral imagery. The initial ATR and Waterfall Plus software used MATRIX as the exploitation software backbone. Additionally, MATRIX employs Ruler as its primary mensuration software; this enables a more accurate measurement of National and ASARS data by using reference sensor models.

C.2 Paragon (ELT 7000)

ELT 7000 combines one of the most scientific exploitation application software packages with above average GUI interfaces. ELT incorporates a host of image manipulation operation, the most significant being a wide range of edge sharpening techniques. These operations provide users a range of methods to enhance images in order to extract the most from available exploitable data. User interface upgrades consist of simple toolbars, pull down windows and mouse operations.

C.3 DIEPS (Version 5.0)

DIEPS was rated as having the best operational user interface of the exploitation packages tested. The DIEPS interface is more user "intuitive"; the general layout and interface appearance enable users with basic softcopy exploitation experience to rapidly assimilate the DIEPS functionality. All the key functions are identified on the overview screen. Annotation functions and reference imagery are easily accessible, as well as zoom, brightness and contrast controls. However, even though this has the best interface package, DIEPS still could incorporate more user centered or controlled functions like automated friskets, and imagery recognition keys.

C.4 Vitec ELT (Version 5.7)

Vitec ELT is one of the more prominent versions of exploitation software in existence. Vitec ELT has been incorporated into the CARS systems and is hosted at several national locations to augment IDEX. Vitec's selection to augment IDEX was primarily based on the VIPER package that optimizes the computer processing to allow for a more natural or near seamless roam or panning capability. In addition to rapid image processing capability, Vitec ELT also incorporates Ruler software for a more precise mensuration capability.

C.5 Waterfall Plus (1.0)

Waterfall Plus is not considered a true exploitation package, but a tool to support rapid identification of militarily significant targets for targeting. Waterfall Plus is the only package that enables users to directly retask U-2 sensors. The Waterfall Plus has been a significant support system to the Real-time Information to the Cockpit program. Other unique features are the ability to monitor an entire mission in a down-selected mode, automatic magnification frames, and pre-sized and formatted image chipping (this expedites transfer of selected critical data to pilots). The Waterfall Plus exploitation components are based on a re-hosted version of Matrix software.

C.6 IDEX

There are three specific functional areas that none of the more modern soft-copy exploitation tools do quite as well as IDEX. These are imagery rotation, zoom or magnification, and roam or panning (scrolling through the image). The IDEX rotation tool enables the analyst to virtually spin the image rapidly in any direction. Zoom or magnification is single button control with a multitude of pre-set ranges. Roaming with IDEX is a natural, seamless transition, whereas with most existing softcopy tools, this process can be choppy and slow.

IDEX is indeed a "Cadillac" of exploitation systems; nonetheless, it is not without drawbacks. Three limitations were identified: cost, size, and adaptability. IDEX terminals and communications requirements make the end cost of the suite more expensive per copy. Therefore, the system is not economical to host. Since IDEX was designed in the mid-80s terminal size was not a real concern; the suite is a rather large workstation which cannot be fielded to meet tactical requirements. Finally, the system was not designed to be truly expandable or to operate with modern media such as live

video feeds or multi-spectral imagery. These limitations are not major impacts to those few major commands that currently operate IDEX.

C.7 Considerations for future softcopy systems

The number one requirement for future softcopy exploitation systems is to truly understand user needs. Tactical imagery analysis does not lend itself to various iterations of imagery manipulation. The users are trying to readout or exploit as much imagery as possible in the shortest time. Whereas, Scientific and Technical users attempt to extract every possible amount of detail from the image. The majority of the software packages reviewed attempt to support both of these roles. However, the problem in supporting both roles is that often the packages do not adequately support either mission. One recommendation is to support plug and play applications (i.e. Ruler as the mensuration software of choice, or separate enhancement packages including actual order of battle count packages, imagery enhancement tools, and imagery reference keys for tactical users). Using this methodology, exploitation could be specifically tailored for the user.

The tactical user may never use applications like histograms or detailed manipulation while exploiting multiple U-2 or UAV missions. Therefore, his tools must be optimized for his performance. It is estimated that imagery support systems will provide analysts with up to 5 terabytes of imagery data per day. It is imperative that future exploitation tools include methods of expediting the exploitation process. One methodology to explore is having the exploitation tool evaluate each image it receives and auto-optimize such features as brightness, contrast, north arrows, auto frisket and edge sharpening (note: the analyst will require over-ride capabilities). This optimization of exploitation functions could help alleviate some of the more time consuming operations the analyst normally performs.